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Applicant
THE ESCHER GROUP, LTD. et al.

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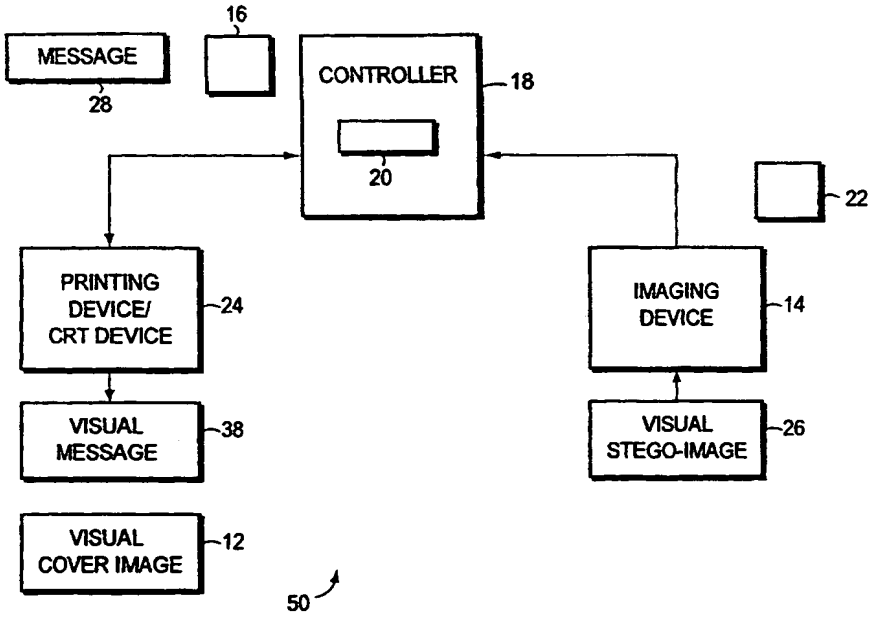

(57) Abstract: Techniques are disclosed for encoding data in, and decoding encoded data from, images. In an embodiment of a technique according to a first aspect of the invention, a function used to encode data in one region of an image is itself encoded in another region of the image. This technique of the present invention may be used to advantage in image-based watermarking applications.

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DATA ENCODING AND DECODING

CROSS-REFERENCE TO RELATED APPLICATION

The subject application claims the priority of commonly-owned, copending U.S. Provisional Patent Application Serial No. 60/139,758, filed June 15, 1999, entitled "Information Hiding." The entirety of said copending application is hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to techniques for data encoding and decoding, and more specifically, to techniques for encoding a data stream in an image, and for decoding such an encoded data stream. As used herein, the term "image" should be viewed broadly as encompassing various types of data sets that may be used in connection with encoding an input data stream. Such data sets may, e.g., represent random or pseudorandom noise phenomena, brightness intensity values of pixels of a digitized visual image, etc. Thus, although in illustrative embodiments of the present invention, the "image" that is used in connection with encoding and decoding of an input data stream actually consists of a set of brightness intensity values of pixels of a digitized visual image, the present invention is not limited to use solely with this type of image data.

Brief Description of Related Prior Art

Steganographic techniques exist in the prior art for modifying a first image (hereinafter termed a "cover image") so as to generate a second image (hereinafter termed a "stego-image") in which an input data stream (hereinafter termed a "message") has been recoverably encoded. In one conventional steganographic technique, the cover image consists of a set of brightness intensity values of pixels of a digitized visual image, and the data values of this cover image are modulated based upon a set of two-dimensionally-varying carrier functions to generate the stego-image. Each of these functions may have either a value of plus or minus unity. In the modulation scheme used in this technique, each data bit of the message is assigned a value of either plus or minus unity, depending upon whether the respective data bit is logically true or false, respectively, the respective bit values comprised in the message resulting from this assignment are multiplied by the respective values of the respective carrier functions, and the resulting products are added to respective predetermined sets of pixel brightness intensity values in the cover image to generate the stego-image. Alternatively, prior to adding the resulting products to the respective pixel intensity values of the cover image, the products may first be multiplied by an empirically-determined scaling or gain factor to improve signal to noise ratio of the encoded data. These respective sets of pixel values are hereinafter termed "image regions," and the size of the image regions is hereinafter termed the "carrier size" of the cover image. By so distributing multiple respective modulations of respective message bit values among the pixel intensity values in respective image regions, it becomes possible to improve message data encoding redundancy, and thereby, to improve the effective signal to noise ratio of the encoded message.

In this prior art technique, the image regions tile the entire stego-image. Thus, the density of data that can be successfully encoded in the stego-image according to this technique is inversely proportional to the carrier size. In order to ensure that the encoded message has an acceptable signal to noise ratio, however, the carrier size cannot be made arbitrarily small.

By sufficiently increasing the magnitude of the scaling factor, it is possible to increase the signal to noise ratio of the encoded message in the stego-image. However, if the magnitude of the scaling factor is made too large, then the distortion (i.e., the modification that is made to the cover image to encode the message therein) reflected in the stego-image may become readily ascertainable from casual analysis of the stego-image. This is undesirable since, ideally, such distortion should be very difficult to detect, in order to ensure maximal security for the encoded message and, if the cover image comprises pixel intensity values of a digitized visual image, to permit the stego-image to have maximal esthetic value. Therefore, in practice, the scaling factor and carrier size should be selected so as to ensure that the density of data encoded, and distortion in, the stego-image are both acceptable given the particular application.

In this prior art technique, in order to decode a respective message bit value encoded in the stego-image, each of the respective pixel intensities in a respective image region is multiplied by the respective values of the respective associated carrier functions (i.e., the respective carrier functions that were used to generate the respective pixel intensity values in the stego-image) to produce a series of products; these products are then summed to produce a respective summation value for the respective image region. If the respective summation value is negative, the respective message bit value encoded in the respective image region is decoded as a "false" data bit, and vice versa.

In one version of the aforesaid conventional steganographic technique, the so-called "direct sequence spread spectrum technique," the values of the carrier functions in the image regions are random or pseudorandom. An advantage of this technique is that, unless the original carrier function is known, it is relatively difficult to decode a message encoded using this technique. A further advantage is that since the encoded data is distributed throughout the spatial frequency spectrum, the distortion in the stego-image resembles grainy "noise" and lacks sharp discontinuities, thereby making detection of such distortion relatively difficult.

Another prior art steganographic technique is the so-called "frequency hopping spread spectrum" technique. In this technique, each message bit value is encoded in the stego-image in accordance with particular spatial frequency bands specified by a pseudo-randomly-generated key. Unfortunately, the mathematical operations required to implement this technique are computationally intensive, and depending upon the particular computational device used to implement the technique in a particular application, it may take significantly longer to perform the computations necessary to implement this technique than the computations necessary to implement other steganographic techniques, including other spread spectrum steganographic techniques.

In each of the aforesaid prior art steganographic techniques, the set of carrier functions that is used to encode the message bit values must be explicitly known in order to be able to decode the encoded message from the stego-image. Explicit knowledge of the carrier functions, however, not only permits the encoded message to be decoded from the stego-image, but also permits the stego-image to be reconverted to the cover image from which the stego-image was generated. This is unfortunate, since it would be desirable in certain applications (e.g., applications in which the encoded mes-

sage in the stego-image serves a "watermarking" role) to provide a steganographic technique wherein it is not necessary to explicitly know the carrier functions in order to be able to decode the encoded message from the stego-image, and also wherein the ability to decode the encoded message does not by itself also grant the ability to generate the cover image from the stego-image, in order to permit the carrier functions to serve essentially as a type of private (i.e., secret) authentication key to be held by a certifying authority (e.g., copyright owner of cover image, government agency, financial institution, etc.). This would be desirable in these applications since this would effectively grant only the certifying authority the ability to generate the cover image from the stego-image, and thereby only permit the authority the ability to generate apparently authorized stego-images, while permitting others the ability to obtain the decoded messages from those stego-images. It would also be desirable to increase the density of the message data that can be encoded in a stego-image, while reducing the degree to which distortion in the stego-image is readily appreciable.

Other examples of prior art steganographic techniques are disclosed in e.g., Smith and Comiskey, "Modulation and Information Hiding In Images," Proceedings of the First Information Hiding Workshop, Isaac Newton Institute, Cambridge, U.K., May 1996, Springer-Verlag Lecture Notes in Computer Science Volume 1174. Unfortunately, each of these other examples of prior art steganographic techniques suffers from the aforesaid and/or other disadvantages and drawbacks.

SUMMARY OF THE INVENTION

In accordance with the present invention, steganographic techniques are provided that are able to overcome the aforesaid and other disadvantages and drawbacks of

the prior art. In one embodiment of a technique in accordance with a first aspect of the present invention, a first function (e.g., a carrier function) to be used in encoding a message is encoded in a first portion of an image, and the message is encoded, based upon the first function, in a second portion of the image. The first function may describe a bitwise modulation to be applied to the message. The first and second portions of the image may each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

In the technique of this first aspect of the present invention, the encoding of the message in the image is carried out in such a way that the message may be decoded from the image based, at least in part, upon respective correlations and anti-correlations between pixels in corresponding image regions in the first and second portions of the image, so as to permit the message to be decoded from the image without explicit knowledge of the carrier function or functions used to encode the message in the image, and such that the ability to decode the encoded message in the image does not by itself also grant the ability to generate the original (i.e., cover) image from the image (i.e., stego-image) containing the encoded message. Advantageously, this permits the carrier function or functions to serve essentially as a type of private authentication key that may be held by a certifying authority so as to grant only to the authority the ability to generate apparently authorized stego-images, while permitting others the ability to obtain decoded messages from those stego-images.

In a technique according to a second aspect of the present invention, a cover image is upsampled in one or more dimensions of the first image so as to generate an upsampled image of higher resolution or larger size than the first image. The upsampled image includes a plurality of respective groups of respectively identical pixels in

the one or more directions of the one or more dimensions of upsampling of the first image. The message is encoded in the upsampled image.

In an embodiment of the technique of the second aspect of the present invention, at least one respective pixel in each of the groups of respectively identical pixels is unaltered as a result of the message being encoded in the upsampled image. Alternatively, the respective identical pixels in each respective group of respectively identical pixels may be changed as a result of the encoding of the message in the upsampled image such that, after the encoding of the message in the upsampled image, respective summations of respective intensity values of the respective identical pixels in each respective group of respectively identical pixels are equal to respective intensity values of respective corresponding pixels in the first image. In either of these two embodiments of the technique according to the second aspect of the present invention, the encoding of the message in the upsampled image may be based, at least in part, upon a bitwise modulation of the message.

Advantageously, it has been found that the technique of the second aspect of the present invention permits a much higher density of message data to be encoded in an image (i.e., the upsampled image) than is possible in the prior art, and also permits substantial reduction in the appreciability of distortion in the upsampled stego-image. Indeed, empirical results indicate that the density of message data that may be effectively encoded into an image using the second technique of the present invention may be ten or more times greater than the density of such data that may be encoded into an image according to the prior art.

Apparatus and methods are also provided that permit messages to be encoded/decoded in and from, respectively, images in accordance with the principles of the techniques of the present invention. These and other features and advantages of the present invention will become apparent as the following Detailed Description proceeds and upon reference to the drawings, in which like numerals depict like parts, and wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a highly schematic diagram illustrating the construction of an apparatus that implements the principles of an embodiment of a technique according to the first aspect of the present invention for the purpose of generating a stego-image containing an encoded message.

Figure 2 is a highly schematic diagram illustrating the construction of an apparatus that implements the principles of an embodiment of a technique according to the first aspect of the present invention for the purpose of decoding an encoded message from a stego-image.

Figure 3 is a highly schematic diagram illustrating the construction of an apparatus that implements the principles of an embodiment of a technique according to the second aspect of the present invention for the purpose of generating a stego-image containing an encoded message.

Figure 4 is a highly schematic diagram illustrating the construction of an apparatus that implements the principles of an embodiment of a technique according to the

second aspect of the present invention for the purpose of decoding an encoded message from a stego-image.

Figure 5 is a symbolic illustration of a stego-image generated by the apparatus of Figure 1, and processed by the apparatus of Figure 2.

Figure 6 is a symbolic illustration of a stego-image generated by the apparatus of Figure 3, and processed by the apparatus of Figure 4.

Although the following Detailed Description will proceed with reference being made to illustrative embodiments and methods of use, it should be understood that the present invention is not limited to these illustrative embodiments and methods of use. Instead, the present invention should be viewed broadly, as being defined only as set forth in the hereinafter appended claims.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

With reference being made to Figures 1-6, illustrative embodiments of techniques of the first and second aspects of the present invention will now be described. Figure 1 is a highly schematic diagram illustrating the construction of an apparatus 10 that implements the principles of an embodiment of the first aspect of the present invention for the purpose of generating a stego-image 26 containing an encoding of a data message 28.

As shown in Figure 1, apparatus 10 includes controller 18. Controller 18 includes computer-readable memory 20 (e.g., comprising random access, read-only, and/or mass storage memory) for storing software programs and associated data structures for execution by one or more processors also comprised in controller 18 and/or

other elements of apparatus 10. When executed by the one or more processors in apparatus 10, the software programs and data structures cause the controller 18 and other elements of apparatus 10 to carry out and/or implement the techniques, functions, and operations described herein as being carried out and/or implemented by controller 18 and other elements of apparatus 10. It will be apparent to those skilled in the art that many types of computer processors and memories may be used in controller 18 without departing from the present invention. For example, controller 18 may comprise one or more Intel 80X86-type processors and associated memory.

Apparatus 10 also comprises an imaging device 14 that includes a conventional imaging, digital camera, one- or two-dimensional array of photoelements (e.g., charge-coupled photosensing elements, etc.) or scanning system that generates, in response to commands received from the controller 18, a digitized image 16 and supplies image 16 to controller 18. Image 16 comprises a set of values that represent pixel brightnesses along the two-dimensional surface of a physical, visual cover image 12 that is input to the device 14 when it is desired to commence generation of the stego-image 26.

Printing device/CRT device 24 comprises a conventional mechanism for interfacing a human user (not shown) to the controller 18 so as to permit the user to control and monitor operation of apparatus 10, for providing the user physical (i.e., hardcopy printed output) representations of visual images and/or other data generated by the apparatus 10 and for providing the user with a display terminal for displaying visual depictions or representations of such images and/or other data. Device 24 may include, for example, one or more conventional computer-user interface devices, such as pointing and keyboard input devices, and a display output device which together permit the human user to input commands to controller 18 to be performed by apparatus 10, and to

receive from controller 18 indication of receipt and progress of apparatus 10 in executing the input commands. Alternatively, or addition thereto, device 24 may include a printing-press or similar printing mechanism controlled by controller 18.

As will be described more fully below, in apparatus 10, when controller 18 receives the digital image 16 from the device 14, controller 18 generates therefrom a digitalized version 22 of stego-image 26, in accordance with the principles of one embodiment of the first aspect of the present invention, based upon a set of carrier functions (symbolically referred to by numeral 30), which image 26 contains an encoding of message 28. As is true in this and the other apparatus shown in Figures 2-4, the respective values of these functions 30 may be either plus or minus unity. The functions 30 and/or message 28 may be stored in memory 20 or may be supplied to the controller 18 from a source external thereto (e.g., a not shown certifying authority connected to the controller 18 via a communications network). The digitized stego-image 22 may be essentially of the same format and may comprise essentially the same types of data as the digitized cover image 16, and when supplied to the device 24 together with appropriate commands from the controller 18, causes device 24 to generate therefrom the visual stego-image 26.

Figure 2 is a highly schematic diagram illustrating the construction of an apparatus 50 that implements the principles of an embodiment of the first aspect of the present invention for the purpose of recovering from the stego-image 26 the digitized cover image 16 and message 28. As shown in Figure 4, apparatus 50 includes controller 18. Controller 18 includes computer-readable memory 20 (e.g., comprising random access, read-only, and/or mass storage memory) for storing software programs and associated data structures for execution by one or more processors also comprised in controller 18

and/or other elements of apparatus 50. When executed by the one or more processors in apparatus 50, the software programs and data structures cause the controller 18 and other elements of apparatus 50 to carry out and/or implement the techniques, functions, and operations described herein as being carried out and/or implemented by controller 18 and other elements of apparatus 50. It will be apparent to those skilled in the art that many types of computer processors and memories may be used in controller 18 of apparatus 50 without departing from the present invention. For example, controller 18 of apparatus 50 may comprise one or more Intel 80X86-type processors and associated memory.

Apparatus 50 also comprises an imaging device 14 that may be of the same construction as the device 14 of apparatus 10. Device 14 of apparatus 50 generates, in response to commands received from the controller 18, digitized image 22 from image 108 and supplies image 22 to controller 18. Image 22 comprises a set of values that represent pixel brightnesses along the two-dimensional surface of a physical, visual stego-image 26 that is input to the device 14 when it is desired to commence recovery of the cover image 16 and/or message 28 from the stego-image 26.

Printing device/CRT device 24 of Figure 2 comprises a conventional mechanism for interfacing a human user (not shown) to the controller 18 so as to permit the user to control and monitor operation of apparatus 50, for providing the user physical (i.e., hardcopy printed output) representations of visual images and/or other data generated by the apparatus 50 and for providing the user with a display terminal for displaying visual depictions or representations of such images and/or other data. Device 24 may include, for example, one or more conventional computer-user interface devices, such as pointing and keyboard input devices, and a display output device which to-

gether permit the human user to input commands to controller 18 to be performed by apparatus 50, and to receive from controller 18 indication of receipt and progress of apparatus 50 in executing the input commands.

As will be described more fully below, in apparatus 50, when controller 18 receives the digital image 22 from the imaging device 14, controller 18 recovers therefrom the message 28 encoded in image 22. Additionally, if controller 18 has been supplied with the functions 30 that were used to encode message 28 into stego-image 22, the controller 18 of apparatus 50 may also recover from the image 28 the digital cover image 16. However, as will be described more fully below, it is a feature and advantage of the technique according to the first aspect of the present invention that unless the controller 18 of apparatus 50 is supplied with these functions 30, it would be very difficult, in practical implementation of apparatus 50, for controller 18 to be programmed in such a way as to recover the image 16 from the image 22. However, it is also a feature and advantage of the first aspect of the present invention that the controller 18 of apparatus 50 need not be supplied with the functions 30 in order to be able to recover the message 28 from the image 22. If controller 18 is given the functions 30, they may be stored in memory 20 of apparatus 50 or may be supplied to the controller 18 of apparatus 50 from a source external thereto (e.g., a not shown certifying authority connected to the controller 18 via a communications network). When supplied to the device 24 together with appropriate commands from the controller 18 of apparatus 50, the image 16 and/or message 28 cause device 24 to generate therefrom the visual cover image 12 and/or a visual (i.e., symbolic written) representation 38 of the message 28, respectively.

Figure 3 is a highly schematic diagram illustrating the construction of an apparatus 100 that implements the principles of an embodiment of the second aspect of the present invention for the purpose of generating a stego-image 108 containing an encoding of a data message 28. As shown in Figure 3, apparatus 100 includes controller 18. Controller 18 includes computer-readable memory 20 (e.g., comprising random access, read-only, and/or mass storage memory) for storing software programs and associated data structures for execution by one or more processors also comprised in controller 18 and/or other elements of apparatus 100. When executed by the one or more processors in apparatus 100, the software programs and data structures cause the controller 18 and other elements of apparatus 100 to carry out and/or implement the techniques, functions, and operations described herein as being carried out and/or implemented by controller 18 and other elements of apparatus 100. It will be apparent to those skilled in the art that many types of computer processors and memories may be used in controller 18 of apparatus 100 without departing from the present invention. For example, controller 18 of apparatus 100 may comprise one or more Intel 80X86-type processors and associated memory.

Apparatus 100 also comprises an imaging device 14 that may be of the same construction as the device 14 of apparatus 10. Device 14 of apparatus 100 generates, in response to commands received from the controller 18, a digitized image 16 and supplies image 16 to upsampler 102. Image 16 comprises a set of values that represent pixel brightnesses along the two-dimensional surface of a physical, visual cover image 12 that is input to the device 14 when it is desired to commence generation of the stego-image 108.

Although upsampler 102 may be thought of as being a separate logical component of apparatus 100, it should be understood that, in practical implementation of apparatus 100, upsampler 102 may be comprised in controller 18 or imaging device 14. Upsampler 102 generates from image 16 another image 104 that is of higher resolution than image 16 but otherwise is identical to image 16. Upsampler 102 accomplishes this by upsampling the image 16 in one or more dimensional directions (i.e., mutually orthogonal dimensional directions 105, 107) of the image 16. As will be described more fully below, the upsampled image 104 that is generated by upsampler 102 as a result of this process contains groups or clusters of pixels (symbolically shown in Figure 3 and collectively referred to by numeral 109) whose respective brightness values are identical to those of corresponding pixels in image 16 from which the higher resolution image 104 was generated. For example, if, as is true in apparatus 100, upsampler 102 is configured to upsample the image 16 by a factor of two in each of the length and width dimensions 105, 107 to generate the upsampled image 104, then the resulting resolution of image 104 is four times greater than that of image 16, and image 104 is composed of contiguous pixel clusters 109 that each comprise four respective contiguous pixels. The brightness values of the four pixels in each respective cluster are identical to each other, but may vary among pixels of different clusters.

Printing device/CRT device 24 comprises a conventional mechanism for interfacing a human user (not shown) to the controller 18 so as to permit the user to control and monitor operation of apparatus 100, for providing the user physical (i.e., hardcopy printed output) representations of visual images and/or other data generated by the apparatus 100 and for providing the user with a display terminal for displaying visual depictions or representations of such images and/or other data. Device 24 may include,

for example, one or more conventional computer-user interface devices, such as pointing and keyboard input devices, and a display output device which together permit the human user to input commands to controller 18 to be performed by apparatus 100, and to receive from controller 18 indication of receipt and progress of apparatus 100 in executing the input commands.

As will be described more fully below, in apparatus 100, when controller 18 receives the upsampled digital image 104 from upsampler 102, controller 18 generates therefrom a digitalized version 106 of stego-image 108, in accordance with the principles of one embodiment of the second aspect of the present invention, based upon a set of carrier functions (symbolically referred to by numeral 30), which image 108 contains an encoding of message 28. The functions 30 and/or message 28 may be stored in memory 20 or may be supplied to the controller 18 from a source external thereto (e.g., a not shown certifying authority connected to the controller 18 via a communications network). The digitized stego-image 106 may be essentially of the same format and may comprise essentially the same types of data as the digitized images 16, 104 and when supplied to the device 24 together with appropriate commands from the controller 18, causes device 24 to generate therefrom the visual stego-image 108.

Figure 4 is a highly schematic diagram illustrating the construction of an apparatus 200 that implements the principles of an embodiment of the second aspect of the present invention for the purpose of recovering from the stego-image 108 the digitized cover image 16 and/or the message 28 encoded in image 108. As shown in Figure 4, apparatus 200 includes controller 18. Controller 18 includes computer-readable memory 20 (e.g., comprising random access, read-only, and/or mass storage memory) for storing software programs and associated data structures for execution by one or more

processors also comprised in controller 18 and/or other elements of apparatus 200. When executed by the one or more processors in apparatus 200, the software programs and data structures cause the controller 18 and other elements of apparatus 200 to carry out and/or implement the techniques, functions, and operations described herein as being carried out and/or implemented by controller 18 and other elements of apparatus 200. It will be apparent to those skilled in the art that many types of computer processors and memories may be used in controller 18 of apparatus 100 without departing from the present invention. For example, controller 18 of apparatus 200 may comprise one or more Intel 80X86-type processors and associated memory.

Apparatus 200 also comprises an imaging device 14 that may be of the same construction as the device 14 of apparatus 10. Device 14 of apparatus 200 generates, in response to commands received from the controller 18, digitized image 106 from image 108 and supplies image 106 to controller 18. Image 106 comprises a set of values that represent pixel brightnesses along the two-dimensional surface of a physical, visual stego-image 108 that is input to the device 14 when it is desired to commence recovery of the cover image 16 and/or message 28 from the stego-image 108.

Printing device/CRT device 24 of Figure 4 comprises a conventional mechanism for interfacing a human user (not shown) to the controller 18 so as to permit the user to control and monitor operation of apparatus 200, for providing the user physical (i.e., hardcopy printed output) representations of visual images and/or other data generated by the apparatus 200 and for providing the user with a display terminal for displaying visual depictions or representations of such images and/or other data. Device 24 may include, for example, one or more conventional computer-user interface devices, such as pointing and keyboard input devices, and a display output device which

together permit the human user to input commands to controller 18 to be performed by apparatus 200, and to receive from controller 18 indication of receipt and progress of apparatus 200 in executing the input commands.

As will be described more fully below, in apparatus 200, when controller 18 receives the digital image 106 from the imaging device 14, controller 18 recovers therefrom, using the functions 30, the encoded message 28 and the image 16. The functions 30 may be stored in memory 20 or may be supplied to the controller 18 from a source external thereto (e.g., a not shown certifying authority connected to the controller 18 via a communications network). When supplied to the device 24 together with appropriate commands from the controller 18, the image 16 and message 28 cause device 24 to generate therefrom the visual cover image 12 and a visual (i.e., written symbolic) representation 38 of the message 28, respectively.

Figure 5 is a symbolic illustration of a digitized stego-image 22 generated by the apparatus 10 of Figure 1, and processed by the apparatus 50 of Figure 2. The manner in which the stego-image 22 is generated by the controller 18 of apparatus 10 will now be described.

After controller 18 of apparatus 10 receives the digitized cover image 16, controller 18 initially processes the image 16 by logically associating together respective pluralities of mutually-continuous pixels in the image 16 into two respective disjoint sets of image regions (collectively referred to in Figure 5 by the numerals 300 and 302, respectively) of equal size (i.e., each of the sets 300, 302 contains the same number of image regions and each of the image regions contains the same number of pixels); each of the image regions 304, 306, 308, and 310 in the first set 300 is associated with a respective image region 312, 314, 316, and 318 in the second set 302. Thus, region 304

is associated with region 312, region 306 is associated with region 314, region 308 is associated with region 316, and region 310 is associated with region 318, respectively. In the illustrative embodiment of the first aspect of the present invention that is implemented by apparatus 10, each of the image regions 304, 306, 308, 310, 312, 314, 316, and 318 has a size of four pixels. It should be noted that the number and size of the image regions in each set 300, 302 described herein is merely for illustrative purposes and may vary depending upon the number of pixels in the image 16 and the number of data bits in the message 28 to be encoded. However, the number of image regions in each set 300, 302 should be equal to the number of data bits in the message 28 to be encoded. Thus, in this illustrative embodiment, the message 28 is four bits in length. The locations of the image regions in the image 22 are predetermined and preprogrammed into the controller 18 of apparatus 10.

In accordance with the first aspect of the present invention, the message 28 is encoded into the image 22 based upon respective correlations and anti-correlations between the respective image regions in the sets 300, 302 that are associated with each other. More specifically, as will be described more fully below, the brightness intensity values of the pixels in each of the image regions of sets 300, 302 are treated as specifying coordinate values of respective vectors, and the data bits of the message 28 are encoded in the image 22 based upon correlations and anti-correlations between these vectors.

For example, for purposes of illustration, it is assumed that the intensity values of the pixels in image region 304 are given by variables a, b, c, and d, respectively; the intensity values of the pixels in image region 306 are given by variables i, j, k, and l, respectively; the intensity values of the pixels in image region 308 are given by vari-

ables q, r, s, and t, respectively; the intensity values of the pixels in image region 310 are given by variables y, z, aa, and bb, respectively. Also, for purposes of illustration, it is assumed that the intensity values of the pixels in image region 312 are given by variables e, f, g, and h, respectively; the intensity values of the pixels in image region 314 are given by variables m, n, o, and p, respectively; the intensity values of the pixels in image region 316 are given by variables u, v, w, and x, respectively; the intensity values of the pixels in image region 318 are given by variables cc, dd, ee, and ff, respectively. The vectors that may be generated from regions 304, 306, 308, 310, 312, 314, 316, and 318 are <a, b, c, d>, <i, j, k, l>, <q, r, s, t>, <y, z, aa, bb>, <e, f, g, h>, <m, n, o, p>, <u, v, w, x>, and <cc, dd, ee, ff>, respectively.

In accordance with this embodiment of the technique of the first aspect of the present invention, the respective vectors (e.g., vectors <a, b, c, d> and <e, f, g, h>) generated from two associated image regions (e.g., regions 304 and 312) are considered to be correlated if the inner product of the respective vectors (calculated after background or DC components have been filtered out from the pixel brightness values from which the respective vectors are generated) is positive. Conversely, the respective vectors are considered to be anti-correlated if the inner product of the respective vectors (calculated after background of DC components have been filtered out from the pixel brightness values from which the respective vectors are generated) is non-positive. The background or DC component may be filtered out from the pixel brightness values from which a respective vector is generated by subtracting from the respective vector the mean of the respective vector (i.e., the inner product of the respective vector with itself). The respective vectors may each also be scaled so as to have the same magnitude. Two associated image regions (e.g., 304 and 312) encode a logically true mes-

sage data bit if the respective vectors generated from the regions' pixel brightness values are correlated. Conversely, two associated image regions encode a logically false message data bit if the respective vectors generated from the regions' pixel brightness values are anti-correlated.

Controller 18 of apparatus 10 is configured to generate the image 22 so as to encode the message 28 therein based upon such correlations and anti-correlations between respective associated image regions of the image 22. That is, controller 18 generates the image 22 from the image 16 by modulating the pixel brightness intensity values of corresponding associated image regions in image 16 such that the resultant associated image regions in image 22 encode message 28 based upon respective correlations and anti-correlations between respective associated image regions in image 22. Each pair of associated image regions in image 22 encodes a single respective bit of the message 28 based upon whether the respective vectors generated from their pixel brightness values are correlated or anti-correlated with each other. It is important to note that, as stated previously, this technique of the present invention is in stark contrast to the prior art, wherein correlations and anti-correlations are made with reference to explicitly known and externally available (i.e., outside of the stego-image) carrier functions.

The manner in which controller 18 of apparatus 10 generates the respective pixel brightness intensity values a, b, c, . . . ff will now be described. Controller 18 of apparatus 10 first assigns each data bit of the message 28 a value of either plus or minus unity, depending upon whether the respective data bit is logically true or false, respectively. The respective message data bit values resulting from this assignment are then multiplied by respective values of respective carrier functions 30, to generate re-

spective products. The respective image regions in the image 16 that correspond to regions 304, 306, 308, 310 are then associated with respective products, in accordance with a predetermined association algorithm, and the respective product associated with each respective corresponding image region in image 16 is added to each of the pixel brightness intensity values in that corresponding image region to generate the pixel intensity values in the image regions 304, 306, 308, 310 of the stego-image 22. Alternatively, prior to adding the resulting products to the respective pixel intensity values of the cover image, the products may first be multiplied by an empirically-determined scaling or gain factor for the purpose of improving encoding signal to noise ratio.

Controller 18 of apparatus 10 adds the respective values of the respective carrier functions 30 that were used to encode the message 28 in image regions 304, 306, 308, and 310 to each of the pixel brightness intensity values in respective corresponding image regions in image 16 to generate the pixel intensity values in the image regions 312, 314, 316, and 318.

By generating the stego-image 22 in this manner, the respective data message bit values are encoded in respective correlations and anti-correlations between respective associated image regions in the stego-image 22. Advantageously, by so encoding the message 28 in the image 22, it is possible to decode the message 28 from the image 22 without explicit knowledge of the carrier functions 30; however, without explicit knowledge of the carrier functions 30, it is also relatively difficult to generate from the image 22 the image 16, since, assuming that the decoder is not provided with the cover image 16, it is relatively difficult to discern without explicit knowledge of the carrier function values 30, the absolute modulations of the pixel brightness intensity values that generated the stego-image 22 from the cover image 16.

In order to decode the message 28 from the stego-image 22, the controller 18 of apparatus 50 first analyzes the stego-image 22 to determine the pixel brightness intensity values of the pixels in the image regions 304, 306, 308, 310, 312, 314, 316, and 318. Controller 18 of apparatus 50 is preprogrammed with the locations and carrier sizes of these image regions in stego-image 22, as well as, which images regions in the sets 300, 302, are respectively associated with each other, and the predetermined algorithm that was used to associate the message data bits with the image regions. Controller 18 of apparatus 50 then determines, based upon this preprogrammed information and the respective correlations and anti-correlations between respective associated image regions, the logical values of the message bits, and assembles these logical values to decode the message 28. If the controller 18 of the apparatus 50 is supplied with the functions 30, the controller may also be programmed to use the knowledge embodied in the functions 30 (i.e., of the absolute modulations of the pixel brightness intensity values that were used to generate the stego-image 22 from the cover image 16) to generate from the image 22 the image 16.

Figure 6 is a symbolic illustration of a digitized stego-image 106 generated by the apparatus 100 of Figure 3, and processed by the apparatus 200 of Figure 4. The manner in which the stego-image 106 is generated by the apparatus 100 will now be described.

After controller 18 in apparatus 100 receives the image 104 from the upsampler 102, the controller 18 analyzes the image 104 to detect and locate therein the clusters 109 of respectively identical pixels therein. As stated previously, each of the clusters 109 contains a respective set of four respectively identical contiguous pixels. After detecting and locating the clusters 109, the controller 18 of apparatus 100 groups the

clusters 109 into blocks which correspond to the image regions (symbolically referred to by numerals 400, 402) in the image 106. Each of the blocks contains a predetermined number of the clusters 109 (e.g., the blocks may each contain 100 of the clusters 109, and be in the form of a 10 cluster by 10 cluster square). It should be noted that the number and size of the blocks, and thus also of the corresponding image regions 400, 402 described herein is merely for illustrative purposes and may vary depending upon the number of pixels in the image 104 and the number of data bits in the message 28 to be encoded. However, the number of blocks and image regions 400, 402 should be equal to the number of data bits in the message 28 to be encoded, since each image region 400, 402 encodes a single respective data bit from the message 28. The assignment of bits of message 28 to be encoded in image regions 400, 402 is in accordance with a predetermined algorithm that may be preprogrammed into controller 18 of apparatus 100. Thus, in this illustrative embodiment of the technique of the second aspect of the present invention, the message 28 is 2 bits in length. The locations of the blocks and corresponding image regions 400, 402 in the image 22 are predetermined and preprogrammed into the controller 18 of apparatus 100.

Controller 18 of apparatus 100 assigns to the respective data bit values of the message 28 either plus or minus unity, depending upon whether the respective data bit value undergoing such assignment is logically true or false. Carrier functions 30 in this embodiment of the second aspect of the present invention comprise a plurality of sets of subcarrier functions. Each set of subcarrier functions comprises four respective values; each of these values may be either plus or minus unity, and subject to this constraint, and the further constraint that the values of the subcarrier functions in each set of subcarrier functions sum to zero, the particular values of the subcarrier functions in

each such set may be selected randomly or pseudo-randomly. The number of sets of subcarrier functions is equal to the number of the clusters 109 in the regions 400, 402 in which message data is encoded, each of the sets of subcarrier functions is randomly associated with a respective one of the clusters 109 in the regions 400, 402, and the respective subcarrier function values in each respective set of subcarrier functions is associated with a respective brightness intensity value of a respective pixel in the respective one of the clusters 109 with which that respective set of subcarrier functions is associated.

In order to encode the message 28 in the image 106, the controller 18 of apparatus 100 multiplies each of the respective assigned values of the message data bits by each of the respective values of the subcarrier functions that is associated with a respective brightness intensity value of a respective pixel in a respective image region associated with that assigned message bit value. The stego-image 106 is then generated by controller 18, by adding the respective resulting products to the respective brightness intensities values of the respective pixels with which the respective subcarrier function values that were used to generate the respective products are associated. Alternatively, prior to adding the resulting products to the respective pixel intensity values of the cover image, the products may first be multiplied by an empirically-determined scaling or gain factor to improve signal to noise ratio of the encoded data.

Further alternatively, the carrier functions 30 may be modified such that each set of subcarrier functions contains only three subcarrier values and these values do not sum to zero. In this alternative, one respective pixel (collectively referred to in Figure 3 by numeral 111) in each of the clusters 109 used to encode message data is not modulated with any of the carrier functions 30. Instead, the one respective pixel in

each of the clusters 109 used to encode message data remains unchanged, in all respects, including brightness intensity value, from its condition in image 104. Various conventional schemes may be used to encode the message data into the remaining pixels of the image 106 (i.e., other than pixels 111). Advantageously, in this alternative, the respective brightness intensity values of these respective pixels 111 may be subtracted from the brightness intensity values of the other pixels in each of the clusters 109 comprising the respective pixels 111 prior to attempting to decode the message data from the image 106 in order to achieve substantial immunity to the effects of noise that may exist in the upsampled cover image 104 in decoding the message 28.

The manner in which the stego-image 106 is processed by the apparatus 200 will now be described. Controller 18 may be preprogrammed with information such as the respective carrier function values, the associations of these values with the respective pixels whose respective brightness intensity values were modulated therewith to encode the message 28 in image 106, the manner in which the respective encoded bits of the message 28 was assigned to the respective image regions 400, 402, and the locations and sizes of the clusters 109 and regions 400, 402. After controller 18 in apparatus 200 receives the stego-image 106 from device 14, the controller 18 decodes the respective message bits from each respective image region 400, 402 by multiplying each of the respective pixel brightness intensity values in each respective image region by the respective value of the respective associated carrier function (i.e., the respective carrier function value that was used to generate the respective pixel intensity value in the stego-image 106) to produce a series of products; these products are then summed in each respective region 400, 402 to produce a respective summation value for the respective image region 400, 402. If the respective summation value is negative, the re-

spective message bit value encoded in the respective image region is decoded as a "false" data bit, and vice versa. The controller 18 also utilizes the aforesaid information in conventional techniques to generate from the image 106 the image 104. The controller 18 of apparatus 200 then appropriately downsamples the image 104 to generate therefrom the image 16.

Although the present invention has been described in connection with specific embodiments and methods of use, it will be appreciated by those skilled in the art that many alternatives, variations and modifications thereof are possible without departing from the present invention. For example, the image misregistration correction techniques disclosed in the aforesaid copending U.S. Provisional Application Serial No. 60/139,758 may be used in conjunction with the techniques of the present invention. Other modifications are also possible.

For example, although the image 16 has been described as being generated by an imaging device 14 from a physical cover image 12 in apparatus 10, 100, if appropriately modified, the apparatus 10, 100 may generate the image 16 using a computer-executed application program. Also alternatively, if appropriately modified, the apparatus 10, 100 may be configured to upload the images 22, 106 to a local or remote server (e.g., a world wide web internet server) for access by others via a computer network (e.g., the internet).

Yet other modifications are also possible. For example, the pixels and/or image regions in the image 22 of Figure 5 may be mutually interleaved among each other and need not be clustered among each other in their respective sets 300, 302.

Additional modifications are also possible. Accordingly, the present invention should be viewed quite broadly, and as being defined only as set forth in the hereinafter appended claims.

What is claimed is:

CLAIMS

1. Method for use in encoding data in an image, comprising:

encoding in a first portion of the image a first function to be used in encoding the data; and

encoding, based upon the first function, in a second portion of the image the data.

2. Method according to claim 1, wherein the first function describes a bitwise modulation to be applied to the data.

3. Method according to claim 1, wherein the first and second portions each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

4. Method according to claim 1, wherein the encoding of the data in the image is such that the data may be decoded from the image based at least in part upon respective correlations and anti-correlations between pixel regions in the first and second portions.

5. Method for use in encoding data in a first image, comprising:

upsampling the first image in at least one dimension of the first image whereby to generate an upsampled image of higher resolution than the first image, the upsampled image including a plurality of respective groups of respectively identical pixels in the direction of the at least one dimension; and

encoding the data in the upsampled image.

6. Method according to claim 5, wherein at least one respective pixel in each of the groups of respectively identical pixels is unchanged after the data has been encoded in the upsampled image.

7. Method according to claim 5, wherein the encoding of the data in the upsampled image is based at least in part upon a bitwise modulation of the data.

8. Method according to claim 5, wherein the respective identical pixels in each said respective group are changed as a result of the encoding of the data in the upsampled image such that, after the encoding, respective summations of respective intensity values of the respective identical pixels in each said respective group are equal to respective intensity values of respective corresponding pixels in the first image.

9. Method for use in decoding data encoded in a first portion of an image, comprising:

decoding the data from the first portion based at least in part upon respective correlations and anti-correlations between corresponding regions in the first portion and a second portion of the image, a function being encoded in the second portion, the function being having been used to encode the data in the first portion.

10. Method for use in decoding data encoded in a first image, comprising:

determining from first groups of pixels in the first image respective bits of the data encoded in the first image, the first image having been generated from a second

image generated by upsampling a third image in at least one dimension such that the second image has a higher resolution than the third image and includes second groups of respectively identical pixels in the direction of the at least one dimension corresponding to the first groups of pixels.

11. Method according to claim 10, wherein the determining of the respective bits is based at least in part upon a subtraction of a respective intensity value of a respective predetermined pixel in each of the first groups of pixels from respective intensity values of the other respective pixels in each of the first groups of pixels, the respective intensity value of the respective predetermined pixel in each of the first groups of pixels being unchanged from a respective intensity value of a respective corresponding pixel in each of the second groups of respective identical pixels.

12. Method according to claim 9, wherein the first function describes a bitwise modulation applied to the data.

13. Method according to claim 9, wherein the first and second portions each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

14. Method according to claim 10, wherein the encoding of the data in the first image is based at least in part upon a bitwise modulation of the data.

15. Method according to claim 10, wherein the respective identical pixels in each of said second groups are changed as a result of the encoding of the data to produce the

first image such that, after the encoding, respective summations of respective intensity values of the respective identical pixels in each of the first groups are equal to respective intensity values of respective corresponding pixels in the second image.

16. Apparatus for use in encoding data in an image, comprising:

an encoder that encodes in a first portion of the image a first function to be used in encoding the data, the encoder also encoding, based upon the first function, in a second portion of the image the data.

17. Apparatus according to claim 16, wherein the first function describes a bitwise modulation to be applied to the data.

18. Apparatus according to claim 16, wherein the first and second portions each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

19. Apparatus according to claim 16, wherein the encoding of the data in the image is such that the data may be decoded from the image based at least in part upon respective correlations and anti-correlations between pixel regions in the first and second portions.

20. Apparatus for use in encoding data in a first image, comprising:

an upsampler that upsamples the first image in at least one dimension of the first image whereby to generate an upsampled image of higher resolution than the first im-

age, the upsampled image including a plurality of respective groups of respectively identical pixels in the direction of the at least one dimension; and

an encoder that encodes the data in the upsampled image.

21. Apparatus according to claim 20, wherein at least one respective pixel in each of the groups of respectively identical pixels is unchanged after the data has been encoded in the upsampled image.

22. Apparatus according to claim 20, wherein the encoding of the data in the upsampled image is based at least in part upon a bitwise modulation of the data.

23. Apparatus according to claim 20, wherein the respective identical pixels in each said respective group are changed as a result of the encoding of the data in the image such that, after the encoding, respective summations of respective intensity values of the respective identical pixels in each said respective group are equal to respective intensity values of respective corresponding pixels in the first image.

24. Apparatus for use in decoding data encoded in a first portion of an image, comprising:

a decoder that decodes the data from the first portion based at least in part upon respective correlations and anti-correlations between corresponding regions in the first portion and a second portion of the image, a function being encoded in the second portion, the function being having been used to encode the data in the first portion.

25. Apparatus for use in decoding data encoded in a first image, comprising:

a decoder that determines from first groups of pixels in the first image respective bits of the data encoded in the first image, the first image having been generated from a second image generated by upsampling a third image in at least one dimension such that the second image has a higher resolution than the third image and includes second groups of respectively identical pixels in the direction of the at least one dimension corresponding to the first groups of pixels.

26. Apparatus according to claim 25, wherein the decoder determines the respective bits based at least in part upon a subtraction of a respective intensity value of a respective predetermined pixel in each of the first groups of pixels from respective intensity values of the other respective pixels in each of the first groups of pixels, the respective intensity value of the respective predetermined pixel in each of the first groups of pixels being unchanged from a respective intensity value of a respective corresponding pixel in each of the second groups of respective identical pixels.

27. Apparatus according to claim 24, wherein the first function describes a bitwise modulation applied to the data.

28. Apparatus according to claim 24, wherein the first and second portions each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

29. Method according to claim 25, wherein the encoding of the data in the first image is based at least in part upon a bitwise modulation of the data.

30. Apparatus according to claim 25, wherein the respective identical pixels in each of said second groups are changed as a result of the encoding of the data to produce the first image such that, after the encoding, respective summations of respective intensity values of the respective identical pixels in each of the first groups are equal to respective intensity values of respective corresponding pixels in the second image.

31. Computer-readable memory comprising computer program instructions for use in encoding data in an image, that when executed cause:

encoding in a first portion of the image a first function to be used in encoding the data; and

encoding, based upon the first function, in a second portion of the image the data.

32. Memory according to claim 31, wherein the first function describes a bitwise modulation to be applied to the data.

33. Memory according to claim 31, wherein the first and second portions each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

34. Memory according to claim 31, wherein the encoding of the data in the image is such that the data may be decoded from the image based at least in part upon respective correlations and anti-correlations between pixel regions in the first and second portions.

35. Computer-readable memory comprising computer program instructions for use in encoding data in a first image, and that when executed cause:

upsampling the first image in at least one dimension of the first image whereby to generate an upsampled image of higher resolution than the first image, the upsampled image including a plurality of respective groups of respectively identical pixels in the direction of the at least one dimension; and

encoding the data in the upsampled image.

36. Memory according to claim 35, wherein at least one respective pixel in each of the groups of respectively identical pixels is unchanged after the data has been encoded in the upsampled image.

37. Memory according to claim 35, wherein the encoding of the data in the upsampled image is based at least in part upon a bitwise modulation of the data.

38. Memory according to claim 35, wherein the respective identical pixels in each said respective group are changed as a result of the encoding of the data in the image such that, after the encoding, respective summations of respective intensity values of the respective identical pixels in each said respective group are equal to respective intensity values of respective corresponding pixels in the first image.

39. Computer-readable memory comprising computer program instructions for use in decoding data encoded in a first portion of an image and that when executed cause:

decoding the data from the first portion based at least in part upon respective correlations and anti-correlations between corresponding regions in the first portion and a second portion of the image, a function being encoded in the second portion, the function being having been used to encode the data in the first portion.

40. Computer-readable memory comprising computer program instructions for use in decoding data encoded in a first image and that when executed cause:

determining from first groups of pixels in the first image respective bits of the data encoded in the first image, the first image having been generated from a second image generated by upsampling a third image in at least one dimension such that the second image has a higher resolution than the third image and includes second groups of respectively identical pixels in the direction of the at least one dimension corresponding to the first groups of pixels.

41. Memory according to claim 40, wherein the determining of the respective bits is based at least in part upon a subtraction of a respective intensity value of a respective predetermined pixel in each of the first groups of pixels from respective intensity values of the other respective pixels in each of the first groups of pixels, the respective intensity value of the respective predetermined pixel in each of the first groups of pixels being unchanged from a respective intensity value of a respective corresponding pixel in each of the second groups of respective identical pixels.

42. Memory according to claim 39, wherein the first function describes a bitwise modulation applied to the data.

43. Memory according to claim 39, wherein the first and second portions each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

44. Memory according to claim 40, wherein the encoding of the data in the first image is based at least in part upon a bitwise modulation of the data.

45. Memory according to claim 40, wherein the respective identical pixels in each of said second groups are changed as a result of the encoding of the data to produce the first image such that, after the encoding, respective summations of respective intensity values of the respective identical pixels in each of the first groups are equal to respective intensity values of respective corresponding pixels in the second image.

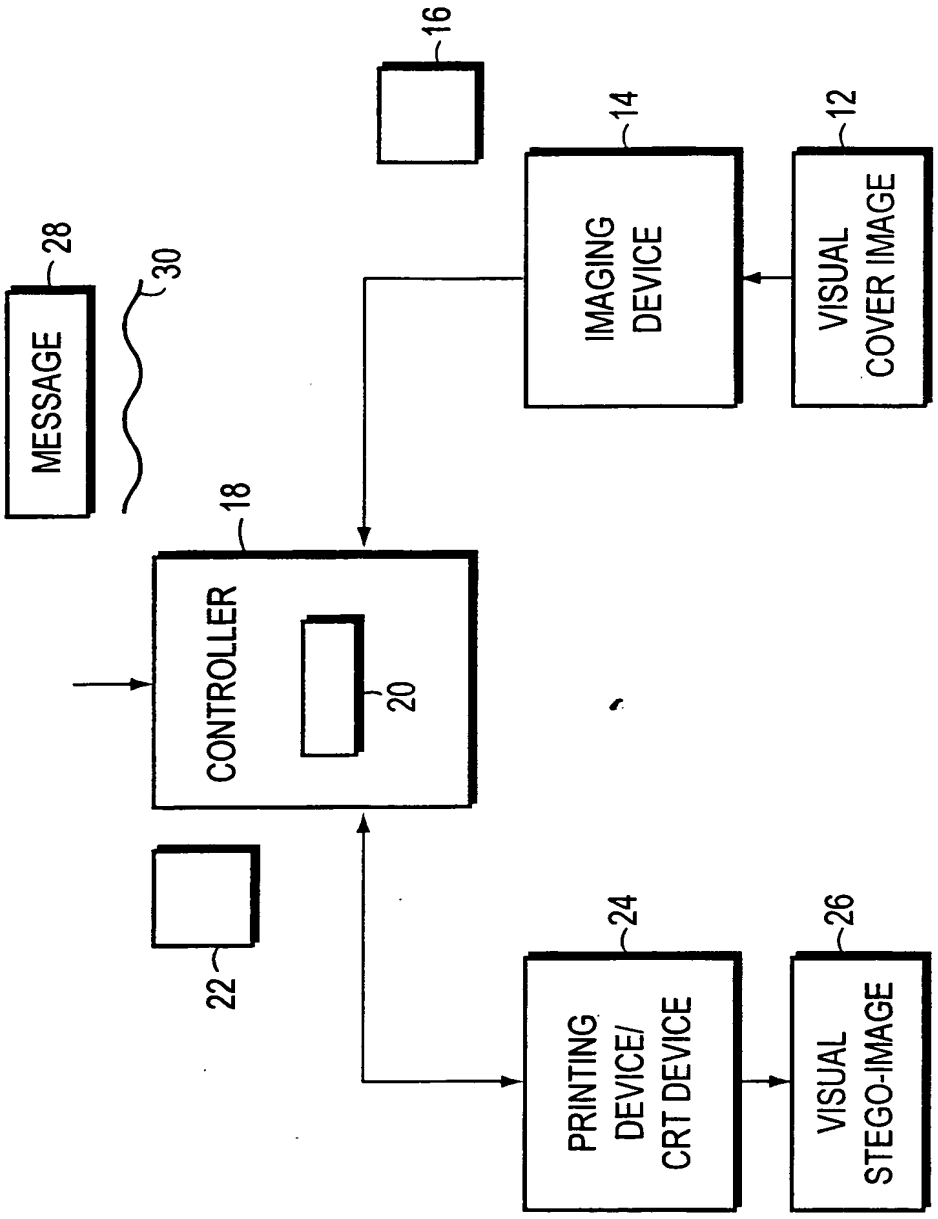

16
14
12
IMAGING DEVICE
VISUAL COVER IMAGE
28
30
MESSAGE
18
CONTROLLER
20
10
22
24
26
PRINTING DEVICE/ CRT DEVICE
VISUAL STEGO-IMAGE

FIG. 1

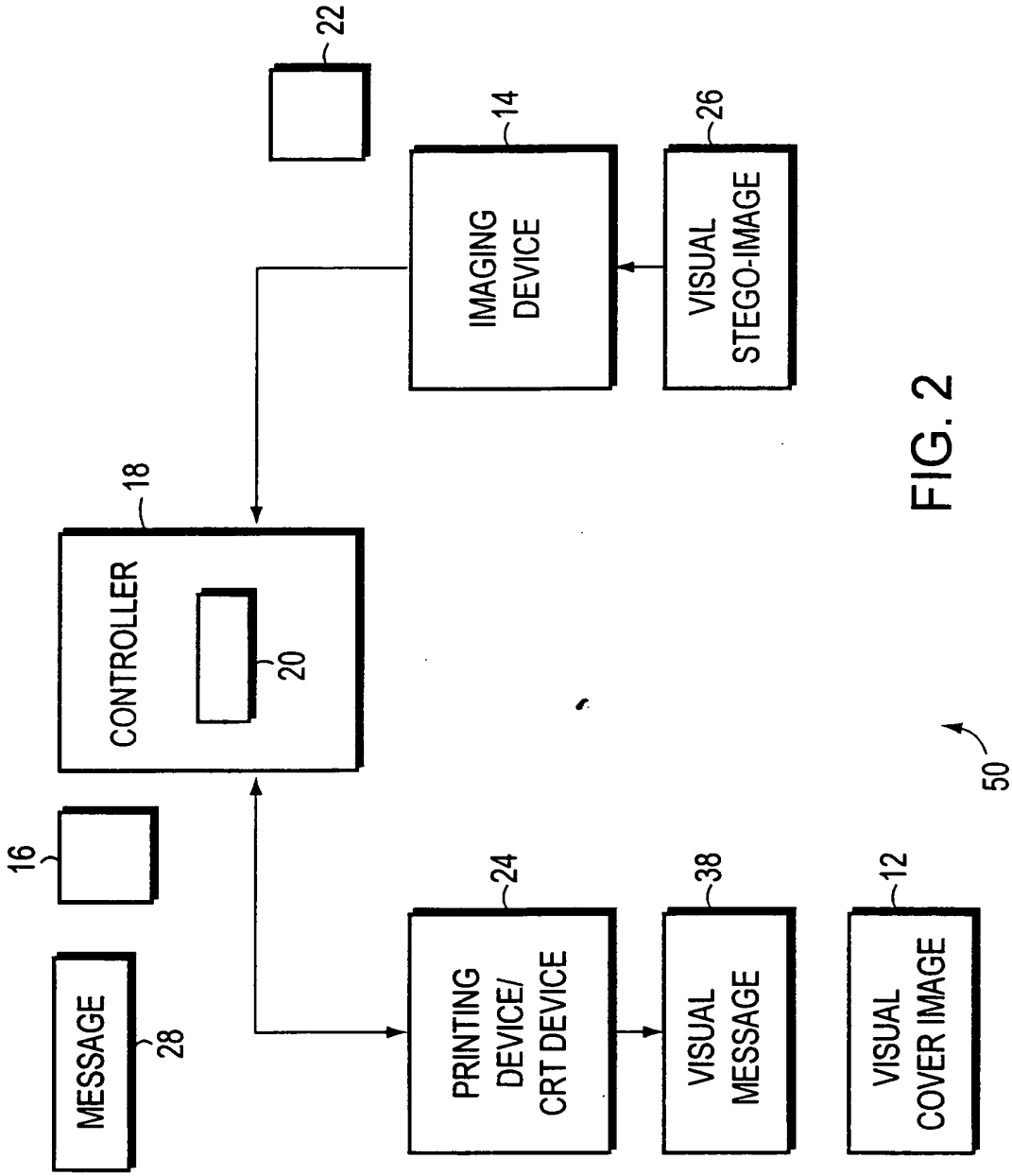

22
14
26
IMAGING DEVICE
VISUAL STEGO-IMAGE
18
CONTROLLER
20
16
MESSAGE
28
24
PRINTING DEVICE/ CRT DEVICE
38
VISUAL MESSAGE
12
VISUAL COVER IMAGE
50

FIG. 2

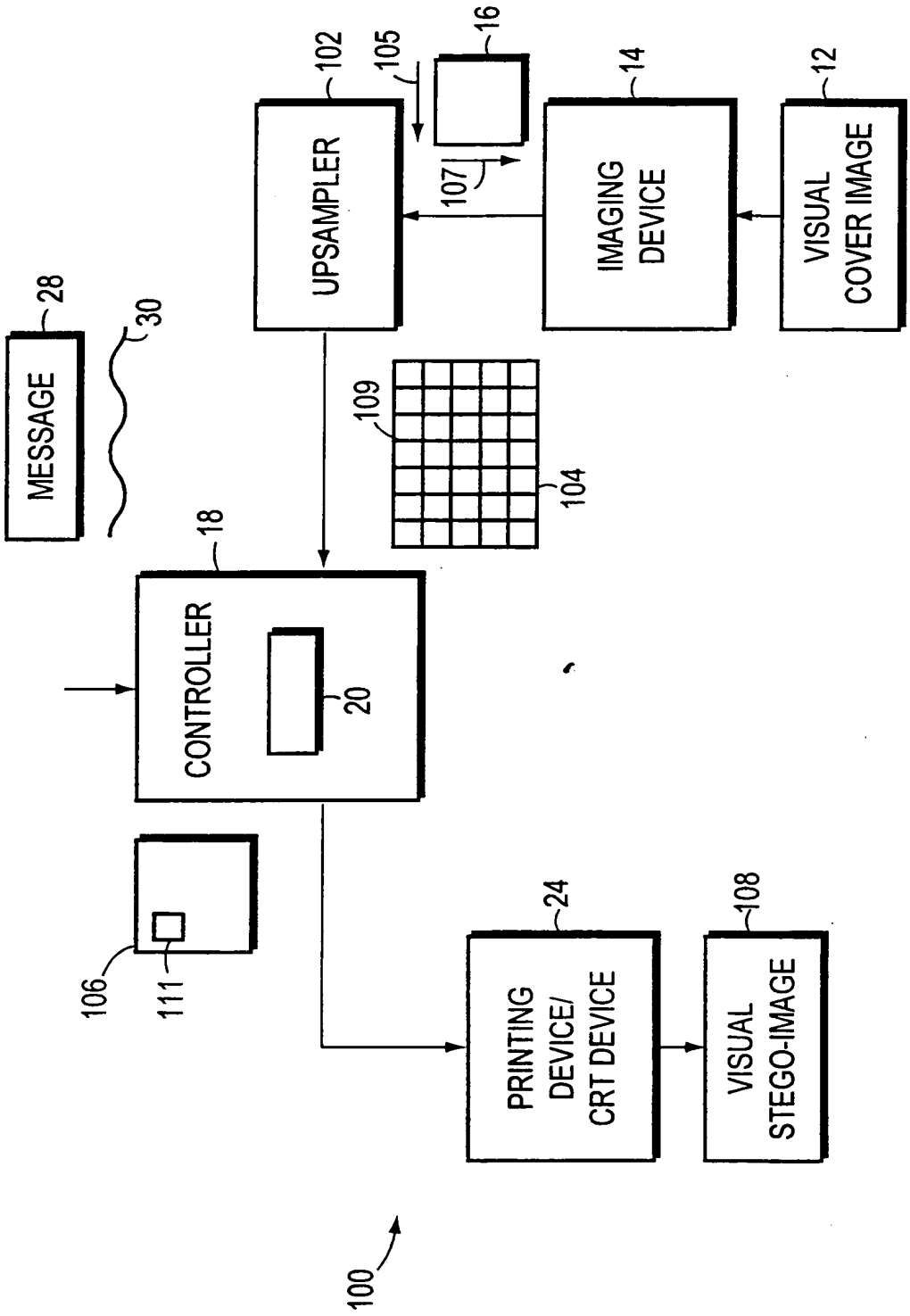
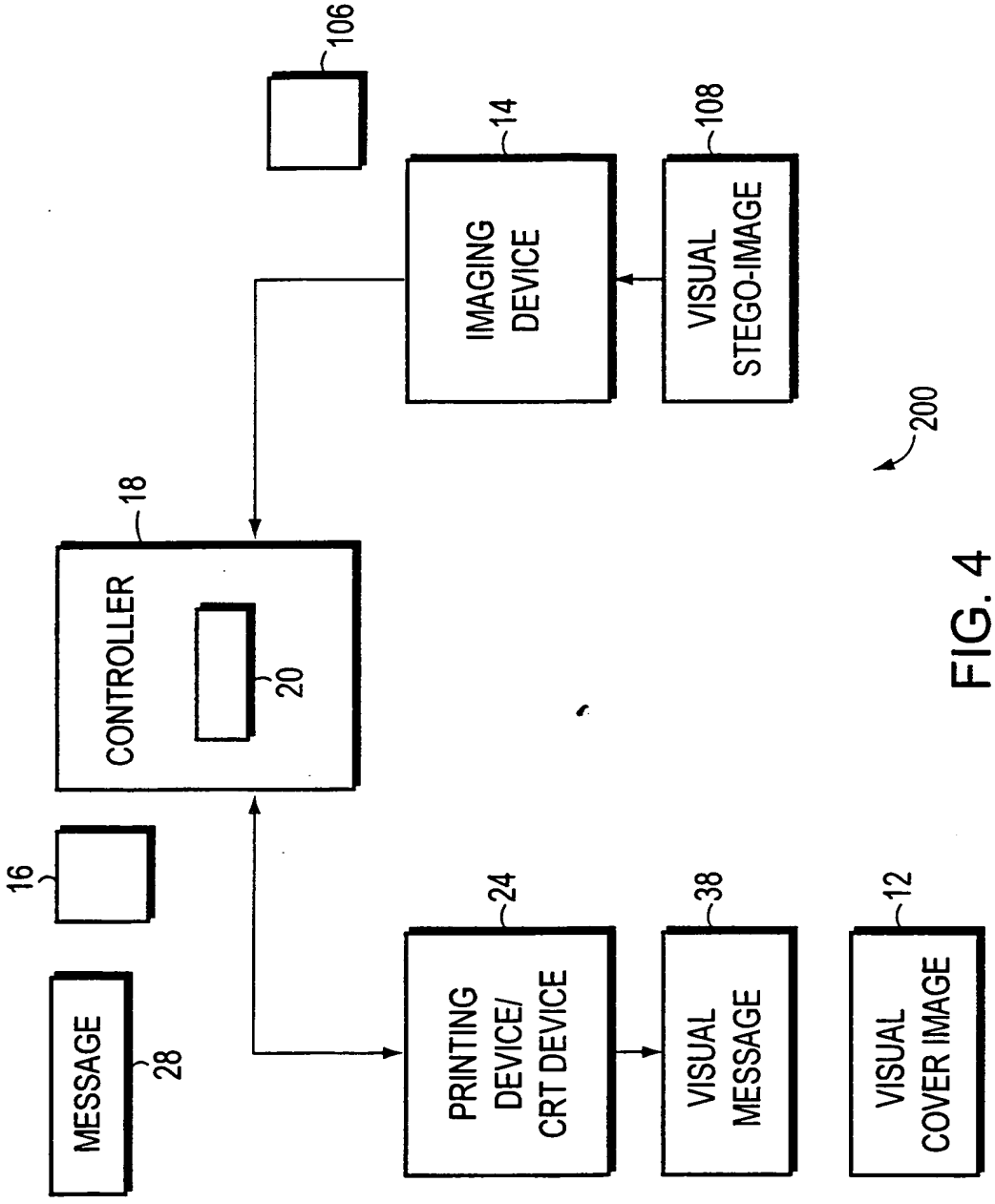

UPSAMPLER
102
105
16
107
IMAGING DEVICE
14
VISUAL COVER IMAGE
12
MESSAGE
28
30
109
104
CONTROLLER
18
20
106
111
PRINTING DEVICE/ CRT DEVICE
24
VISUAL STEGO-IMAGE
108
100

FIG. 3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14
108
IMAGING DEVICE
VISUAL STEGO-IMAGE
200
18
CONTROLLER
20
16
MESSAGE
28
24
PRINTING DEVICE/ CRT DEVICE
38
VISUAL MESSAGE
12
VISUAL COVER IMAGE

FIG. 4

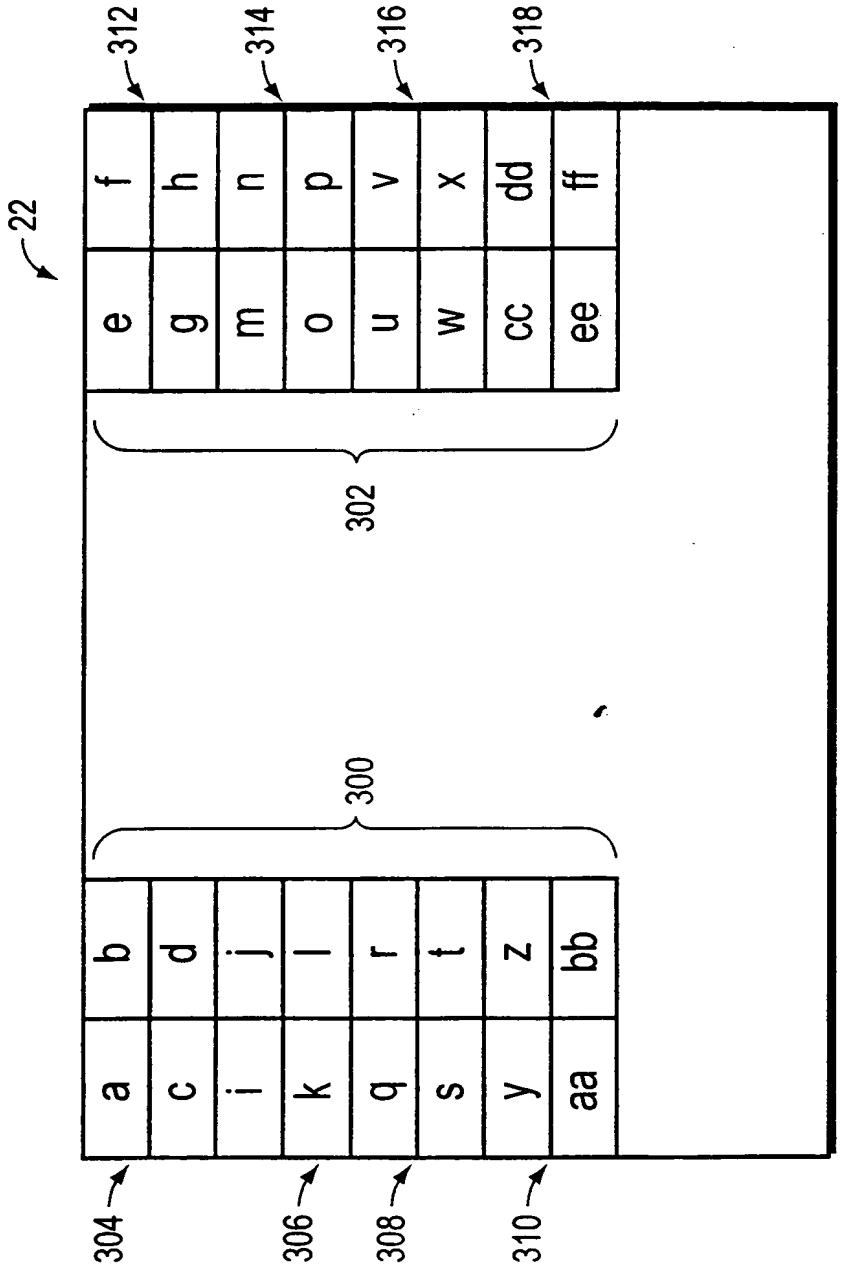
22
312
314
316
318
f
h
n
p
v
x
dd
ff
e
g
m
o
u
w
cc
ee
302
300
b
d
j
l
r
t
z
bb
a
c
i
k
q
s
y
aa
304
306
308
310

FIG. 5

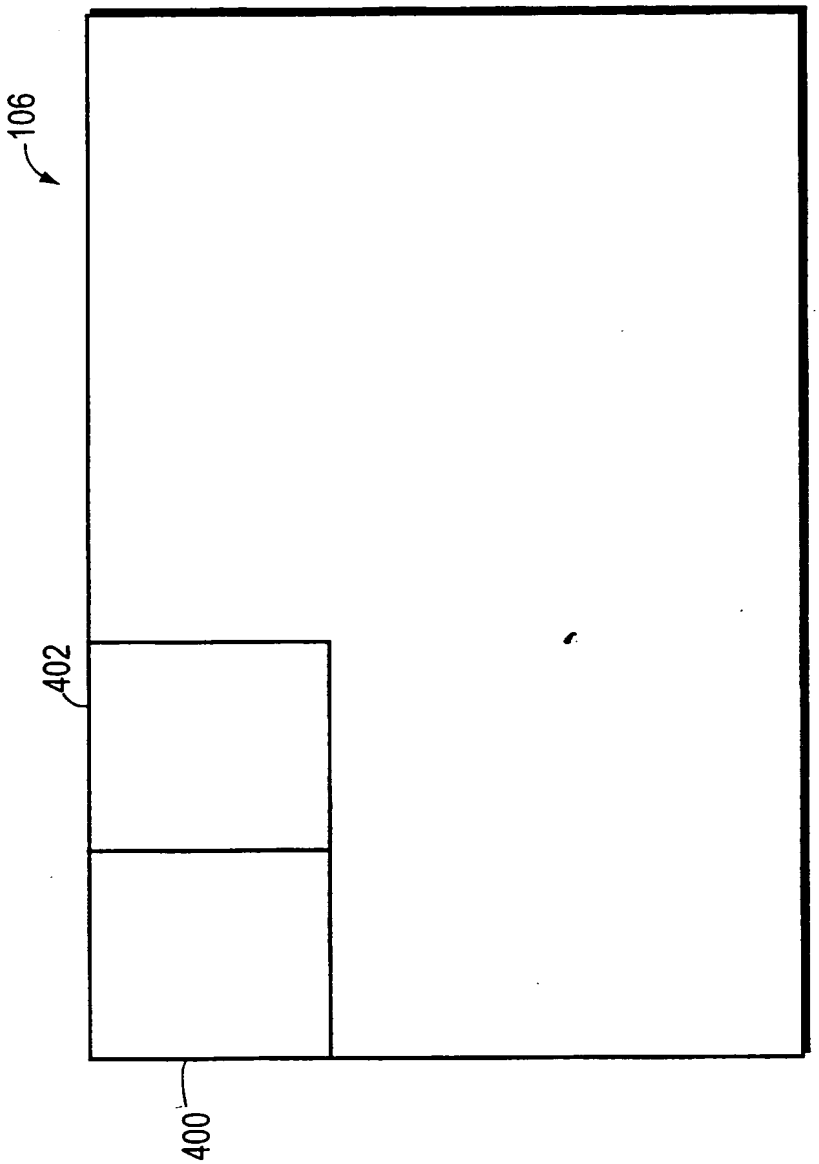

FIG. 6

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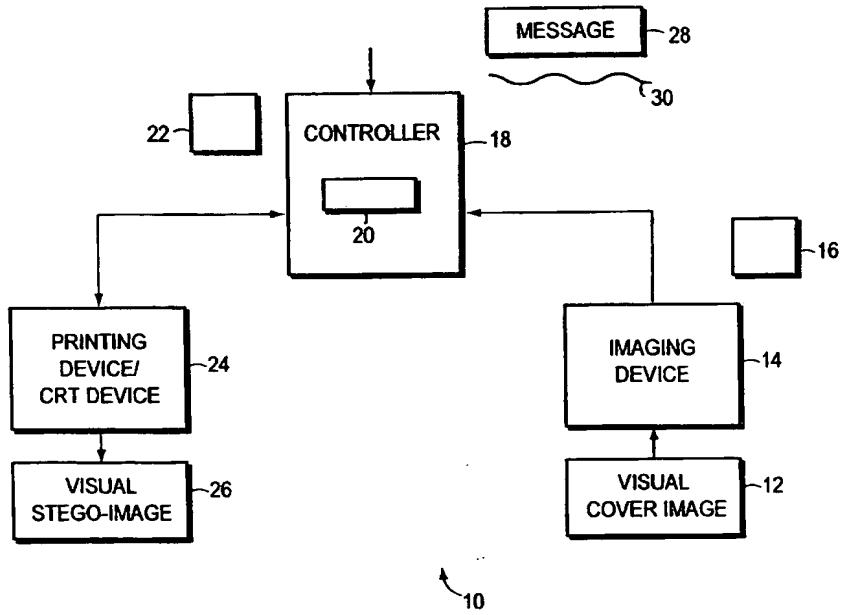
[Continued on next page]

(54) Title: DATA ENCODING AND DECODING



(57) Abstract: Techniques are disclosed for encoding data in, and decoding encoded data from, images. In an embodiment of a technique according to a first aspect of the invention, a function used to encode data in one region of an image is itself encoded in another region of the image. This technique of the present invention may be used to advantage in image-based watermarking applications.

WO 00/78032 A3

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
103140-7PCT		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US00/16099	13/06/2000	15/06/1999
International Patent Classification (IPC) or national classification and IPC G06T1/00		
Applicant THE ESCHER GROUP, LTD. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 9 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 13 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☒ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
11/01/2001	05.10.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Meinl, W Telephone No. +49 89 2399 2532

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/US00/16099

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-4,7-28	as originally filed			
5,6,6a	as received on	29/08/2001	with letter of	27/08/2001

Claims, No.:

1-45	as received on	29/08/2001	with letter of	27/08/2001

Drawings, sheets:

1-6	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

   - ☐ restricted the claims.
   - ☒ paid additional fees.
   - ☐ paid additional fees under protest.
   - ☐ neither restricted nor paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

   - ☐ complied with.
   - ☐ not complied with for the following reasons:

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

   - ☒ all parts.
   - ☐ the parts relating to claims Nos. .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	8,11,23,30,38,45
	No:	Claims	1-4,9,12,13,16-19,24,31-34,39

Inventive step (IS)	Yes:	Claims	8,11,23,30,38,45
	No:	Claims	5-7,10,14,15,20-22,25-29,35-37,40-44
Industrial applicability (IA)	Yes:	Claims	1-45
	No:	Claims	

2. Citations and explanations
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Re. Section IV (Lack of unity of invention)

1. The following documents are referred to in this communication; the numbering will be adhered to in the rest of the procedure:-

   D1, D2: The documents of the International Search Report in the order as they are listed therein.

   D3: J. R. Smith and B. O. Comiskey: "Modulation and Information Hiding in Images", Lecture Notes in Computer Science, Springer Verlag, NY, US, Vol.1174, pp 207-226, May 1996; XP000992404 (cited at page 5 of the description).

2. The application does not meet the requirement for unity of invention of Articles 3(4)(iii), 34(3) and Rule 13.1 PCT.

2.1 The application contains **two** different groups of claimed inventions:-

Claimed invention (i): Independent claims 1, 9, 16, 24, 31 and 39 concern methods and devices for encoding and decoding of data in a first and second portion of an image using the same encoding function.

Claimed invention (ii): Independent claims 5, 10, 20, 25, 35 and 40 concern methods and devices for encoding and decoding of data in an upsampled image of higher resolution.

2.2 While one may say that the claimed inventions (i) and (ii) both relate to encoding of data in an image, or hiding of information in an image, this nevertheless does not provide for the required novel and inventive concept as this generic concept is known from each of the documents **D1** to **D3.**

Re. Sections V, VIII (Novelty, Inventive step and Observations)

Claimed invention (i): Claims 1, 9, 16, 24, 31 and 39.

3. The claims are not clear (Art.6 PCT).

3.1 In claim 1 essential features are missing.
In the general description of the first aspect of the invention at page 6 and the description of an embodiment of the first aspect at pp.19-21 it is repeatedly stressed that the notion of respective correlations and anti-correlations between pixels in the first and second portion of the image is a key feature of the invention. Such feature is however only specified in dependent claim 4.

3.2 Moreover, in claim 1 it is completely unclear how the data is actually encoded, bearing in mind that, according to description, no explicitly known set of carrier functions as in the prior art shall be employed (page 4, last paragraph).

3.3 The independent claims for encoding and decoding are not consistent in their scope, thus rendering the whole set of claims not concise (Art.6 PCT).
For instance, claim 9 recites the feature "correlations and anti-correlations", while this feature is missing in claim 1.

4. Novelty.

4.1 It seems that the claims 1-4, 9, 12-13, 16-19, 31-34 and 39 lack novelty over the "Patchwork algorithm" disclosed in document **D3**, see page 212, 3rd complete paragraph. In the Patchwork algorithm, a sequence of random pairs of pixels is chosen. The brightness value of one member of the pair is increased and the other decreased by the same amount.
In terms of the claims, the Patchwork algorithm uses pixels of a "first and second portion of the image", and also uses "correlation and anti-correlation" of some kind

between pixel pairs of the two image portions.

4.2 It is noted that the mere notion of "correlation and anti-correlation" as in claim 4 or in claim 9 is too unspecific to establish a clear distinction over D3. From the description at pages 19-21 it appears that the distinction over D3 actually resides firstly in the way in which the correlations and anti-correlations are calculated (i.e. the sign of the inner product ..., see page 20, lines 12-20), and secondly in the fact that locations of the first and second image portions are predetermined (page 19, line 11). Otherwise one would need explicit knowledge of the carrier functions for decoding as this is the case in most of the prior art. In this respect in claim 3 the feature "arbitrarily selected ... sets" is not understood and may even render the whole set of claims unclear.

Claimed invention (ii): Claims 5, 10, 20, 25, 35 and 40.

6. Claim 5 is unclear (Art.6 PCT). The claim contains a disclaimer-type feature ("interference ... is eliminated") which is not appropriate at that place. Moreover, with this disclaimer-type feature the claim merely gives a result to be achieved without any indication, i.e. a positive limiting functional feature, as to how this is done.

7. Claim 5 does not involve an inventive step (Art.33(3) PCT).

7.1 When the last feature of the claim is disregarded for its lack of clarity, the following applies:
The first feature ("upsampling ...") is trivial per se and commonly known for converting the image resolution e.g. for adaptation to a certain output device such as a printer. The second feature ("encoding") merely states that data is to be encoded in the upsampled image and is trivial per see too.

7.2 The mere combination of "upsampling" and "encoding" is a juxtaposition of per se known features and thus trivial; in the current unclear wording of the claim there is no surprising effect apparent regarding the mere feature combination.

7.3 Prior art.
Generic concepts of encoding of data in raw and compressed (video) images are known from **D2**, see items 3. and 4.
It is however noted that a technique of encoding of data in upsampled images is not known from the prior art on file.

8. Dependent claims.
- Claim 6 seems to be unclear too (Art.6 PCT). Again, it is not clear what actually happens when encoding the data.
- Claim 7: The feature "bitwise modulation" is trivial in the context of stego-images, see each of documents D1 to D3.
- Claim 8: The features of claim 8 are not known nor obvious from the prior art on file.

9. The above objections apply to the device and memory claims accordingly.

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sage in the stego-image serves a "watermarking" role) to provide a steganographic technique wherein it is not necessary to explicitly know the carrier functions in order to be able to decode the encoded message from the stego-image, and also wherein the ability to decode the encoded message does not by itself also grant the ability to generate the cover image from the stego-image, in order to permit the carrier functions to serve essentially as a type of private (i.e., secret) authentication key to be held by a certifying authority (e.g., copyright owner of cover image, government agency, financial institution, etc.). This would be desirable in these applications since this would effectively grant only the certifying authority the ability to generate the cover image from the stego-image, and thereby only permit the authority the ability to generate apparently authorized stego-images, while permitting others the ability to obtain the decoded messages from those stego-images. It would also be desirable to increase the density of the message data that can be encoded in a stego-image, while reducing the degree to which distortion in the stego-image is readily appreciable.

Other examples of prior art steganographic techniques are disclosed in e.g., Smith and Comiskey, "Modulation and Information Hiding In Images," Proceedings of the First Information Hiding Workshop, Isaac Newton Institute, Cambridge, U.K., May 1996, Springer-Verlag Lecture Notes in Computer Science Volume 1174. European Patent Application EP 0 845 758 describes a system in which an encoder encodes a first portion of an image using a hash functioin and encodes the result in a second portion of the image. A user checks the image by again encoding the first portion of the image using the same hash function and comparing the result with the hash value that is encoded into the second

portion of the image. Unfortunately, each of these other examples of prior art steganographic techniques suffers from the aforesaid and/or other disadvantages and drawbacks.

SUMMARY OF THE INVENTION

In accordance with the present invention, steganographic techniques are provided that are able to overcome the aforesaid and other disadvantages and drawbacks of the prior art. In one embodiment of a technique in accordance with a first aspect of the present invention, a first portion of an image is encoded in accordance with a first function (e.g., a carrier function) that is to be used in encoding a message into a second portion of the image. The first function may describe a bitwise modulation to be applied to the message. The first and second portions of the image may each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

In the technique of this first aspect of the present invention, the encoding of the message in the image is carried out in such a way that the message may be decoded from the image based, at least in part, upon respective correlations and anti-correlations between pixels in corresponding image regions in the first and second portions of the image, so as to permit the message to be decoded from the image without explicit knowledge of the carrier function or functions used to encode the message in the image, and such that the ability to decode the encoded message in the image does not by itself also grant the ability to generate the original (i.e., cover) image from the image (i.e., stego-image) containing the encoded message. Advantageously, this permits the carrier function or functions to

serve essentially as a type of private authentication key that may be held by a certifying authority so as to grant only to the authority the ability to generate apparently authorized stego-images, while permitting others the ability to obtain decoded messages from those stego-images.

In a technique according to a second aspect of the present invention, a cover image is upsampled in one or more dimensions of the first image so as to generate an upsampled image of higher resolution or larger size than the first image. The upsampled image includes a plurality of respective groups of respectively identical pixels in

1. Method for use in encoding data in an image, comprising:

manipulating one or more pixels in a first portion of the image in accordance with a first function to be used in encoding the data; and

encoding the data in a second portion of the image by manipulating one or more pixels in the second portion in accordance with the first function and the data.

2. Method according to claim 1, wherein the first function describes a bitwise modulation to be applied to the data.

3. Method according to claim 1, wherein the first and second portions each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

4. Method according to claim 1, wherein the encoding of the data in the image is such that the data may be decoded from the image based at least in part upon respective correlations and anti-correlations between pixel regions in the first and second portions.

5. Method for use in encoding data in a first image, comprising:

upsampling the first image in at least one dimension of the first image to generate an upsampled image of higher resolution than the first image, the upsampled image including a plurality of respective groups of respectively identical pixels in the direction of the at least one dimension; and

encoding the data in the upsampled image to produce an encoded upsampled image in which interference of the first image with the encoded data is eliminated.

6. Method according to claim 5, wherein in each of the groups of respectively identical pixels the pixel intensity value of at least one pixel remains the same after the data has been encoded in the upsampled image.

7. Method according to claim 5, wherein the encoding of the data in the upsampled image is based at least in part upon a bitwise modulation of the data.

8. Method according to claim 5, wherein ~~the~~ respective identical pixels in each said respective group are changed as a result of the encoding of the data in the upsampled image such that, after the encoding, respective summations of respective intensity values of the respective pixels in each said respective group are equal to respective intensity values of respective corresponding pixels in the first image.

9. Method for use in decoding data encoded in a first portion of an image, comprising:

decoding the data from the first portion based at least in part upon respective correlations and anti-correlations between corresponding regions in the first portion and a second portion of the image, pixels in the regions in the second portion having been manipulated in accordance with one or more respective functions and the pixels in the corresponding regions in the first portion having been manipulated in accordance with the one or more respective functions and the data to encode the data in the first portion.

10. Method for use in decoding data encoded in a first image, comprising:

determining from first groups of pixels in the first image respective bits of the data encoded in the first image, the first image having been generated from a second image generated by upsampling a third image in at least one dimension such that the second image has a higher resolution than the third image and includes second groups of respectively identical pixels in the direction of the at least one dimension, with the second groups corresponding to the first groups of pixels and the first image includes the data therein such that interference of the third image and the encoded data is eliminated.

11. Method according to claim 10, wherein the determining of the respective bits is based at least in part upon a subtraction of an intensity value of a respective predetermined pixel in each of the respective first groups of pixels from the intensity values of the other pixels in the same group the respective predetermined pixels in each of the first groups of pixels having the same intensity values as the respective pixels in the corresponding second groups of pixels.

12. Method according to claim 9, wherein the first function describes a bitwise modulation applied to the data.

13. Method according to claim 9, wherein the first and second portions each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

14. Method according to claim 10, wherein the encoding of the data in the first image is based at least in part upon a bitwise modulation of the data.

15. Method according to claim 10, wherein the intensity values of the respective pixels in each of said second groups are changed as a result of the encoding of the data to produce the first groups in the first image such that, after the encoding, respective summations of the intensity values of the pixels in each of the respective first groups are equal to respective intensity values of respective corresponding pixels in the second image.

16. Apparatus for use in encoding data in an image, comprising:

an encoder that manipulates pixels in a first portion of the image in accordance with a first function to be used in encoding the data, and

the encoder encoding the data in a second portion of the image by manipulating pixels in the second portion in accordance with the first function and the data.

17. Apparatus according to claim 16, wherein the first function describes a bitwise modulation to be applied to the data.

18. Apparatus according to claim 16, wherein the first and second portions each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

19. Apparatus according to claim 16, wherein the encoding of the data in the image is such that the data may be decoded from the image based at least in part upon respective correlations and anti-correlations between pixel regions in the first and second portions.

20. Apparatus for use in encoding data in a first image, comprising:

an upsampler that upsamples the first image in at least one dimension of the first image to generate an upsampled image of higher resolution than the first image, the upsampled image including a plurality of respective groups of respectively identical pixels in the direction of the at least one dimension; and

an encoder that encodes the data in the upsampled image to produce an encoded upsampled image in which the first image does not interfere with the enoded data.

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21. Apparatus according to claim 20, wherein the encoder encodes the data into the image by changing all but at least one respective pixel in each of the groups of respectively identical pixels.

22. Apparatus according to claim 20, wherein the encoding of the data in the upsampled image is based at least in part upon a bitwise modulation of the data.

23. Apparatus according to claim 20, wherein the encoder changes the respective identical pixels in each said respective group as a result of the encoding of the data in the image such that, after the encoding, respective summations of respective intensity values of the respective pixels in each said respective group are equal to respective intensity values of respective corresponding pixels in the first image.

24. Apparatus for use in decoding data encoded in a first portion of an image, comprising:

a decoder that decodes the data from the first portion based at least in part upon respective correlations and anti-correlations between corresponding regions in the first portion and a second portion of the image, the second portion including pixels that have been manipulated in accordance with a function that was used to encode the data in the first portion.

25. Apparatus for use in decoding data encoded in a first image, comprising:

a decoder that determines from first groups of pixels in the first image respective bits of the data encoded in the first image, the first image having been generated from a second image generated by upsampling a third image in at least one dimension such that the second image has a higher resolution than the third image and includes second groups of respectively identical pixels in the direction of the at least one dimension corresponding to the first groups of pixels, and the first image includes the data therein such that interference of the third image and the encoded data is eliminated.

26. Apparatus according to claim 25, wherein the decoder determines the respective bits based at least in part upon a subtraction of a respective intensity value of a respective predetermined pixel in each of the first groups of pixels from respective intensity values of the other respective pixels in the same groups of pixels, the respective intensity values of the respective predetermined pixels in the respective first groups of pixels being the same as the respective intensity values respective corresponding pixels in respective corresponding second groups of respective identical pixels.

27. Apparatus according to claim 24, wherein the first function describes a bitwise modulation applied to the data.

28. Apparatus according to claim 24, wherein the first and second portions each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

29. Method according to claim 25, wherein the encoding of the data in the first image is based at least in part upon a bitwise modulation of the data.

30. Apparatus according to claim 25, wherein the respective identical pixels in each of said second groups are changed as a result of the encoding of the data to produce the first image such that, after the encoding, respective summations of respective intensity values of the respective pixels in each of the first groups are equal to respective intensity values of respective corresponding pixels in the second image.

31. Computer-readable memory comprising computer program instructions for use in encoding data in an image, that when executed cause:

manipulating pixels in a first portion of the image in accordance with a first function used in encoding the data; and

encoding the data in a second portion of the image by manipulating pixels in the second portion in accordance with the first function and the data.

32. Memory according to claim 31, wherein the first function describes a bitwise modulation to be applied to the data.

33. Memory according to claim 31, wherein the first and second portions each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

34. Memory according to claim 31, wherein the encoding of the data in the image is such that the data may be decoded from the image based at least in part upon respective correlations and anti-correlations between pixel regions in the first and second portions.

35. Computer-readable memory comprising computer program instructions for use in encoding data in a first image, and that when executed cause:

upsampling the first image in at least one dimension of the first image to generate an upsampled image of higher resolution than the first image, the upsampled image including a plurality of respective groups of respectively identical pixels in the direction of the at least one dimension; and

encoding the data in the upsampled image to produce an encoded upsampled image in which the first image does not interfere with the encoded data do not interfere.

36. Memory according to claim 35, wherein at least one respective pixel in each of the groups of respectively identical pixels retains the same intensity value after the data has been encoded in the upsampled image.

37. Memory according to claim 35, wherein the encoding of the data in the upsampled image is based at least in part upon a bitwise modulation of the data.

38. Memory according to claim 35, wherein the respective identical pixels in each said respective group are changed as a result of the encoding of the data in the image such that, after the encoding, respective summations of respective intensity values of the respective pixels in each said respective group are equal to respective intensity values of respective corresponding pixels in the first image.

39. Computer-readable memory comprising computer program instructions for use in decoding data encoded in a first portion of an image and that when executed cause:

decoding the data from the first portion based at least in part upon respective correlations and anti-correlations between corresponding regions in the first portion and a second portion of the image, pixels in the regions in the second portion having been manipulated in accordance with a that was used to encode the data in the first portion.

40. Computer-readable memory comprising computer program instructions for use in decoding data encoded in a first image and that when executed cause:

determining from first groups of pixels in the first image respective bits of the data encoded in the first image, the first image having been generated from a second image generated by upsampling a third image in at least one dimension such that the second image has a higher resolution than the third image and includes second groups of respectively identical pixels in the direction of the at least one dimension corresponding to the first groups of pixels, the encoding of the data in the second image producing a first image in which the third image does not interfere with the encoded data.

41. Memory according to claim 40, wherein the determining of the respective bits is based at least in part upon a subtraction of respective intensity values of respective predetermined pixels in each of the first groups of pixels from respective intensity values of the other respective pixels in each of the first groups of pixels, the respective intensity values of the respective predetermined pixels in the respective first groups of pixels being the same as the respective intensity values of respective corresponding pixels in the corresponding second groups of respective identical pixels.

42. Memory according to claim 39, wherein the first function describes a bitwise modulation applied to the data.

43. Memory according to claim 39, wherein the first and second portions each comprise respective arbitrarily-selected disjoint sets of pixels in the image.

44. Memory according to claim 40, wherein the encoding of the data in the first image is based at least in part upon a bitwise modulation of the data.

45. Memory according to claim 40, wherein the respective identical pixels in each of said second groups are changed as a result of the encoding of the data to produce the first image such that, after the encoding, respective summations of respective intensity values of the respective pixels in each of the first groups are equal to respective intensity values of respective corresponding pixels in the second image.

103140-0007 PCT MYT/PAS

CN Reply Wr. Op. 7/28/01
Reply Writ. opinion 8/28/01

PATENT COOPERATION TREATY

From the:
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

SHEEHAN, Patricia A.
Cesari & McKenna,LLP
88 Black Falcon Avenue
Boston, MA 02210
ETATS-UNIS D'AMERIQUE

PCT

N/A

WRITTEN OPINION

(PCT Rule 66)

Date of mailing *(day/month/year)*	28.06.2001
Applicant's or agent's file reference: 103140-7PCT	**REPLY DUE** **within 2 month(s)** from the above date of mailing

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US00/16099	13/06/2000	15/06/1999

International Patent Classification (IPC) or both national classification and IPC

G06T1/00

Applicant

THE ESCHER GROUP, LTD. et al.

1. This written opinion is the **first** drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

I	☒	Basis of the opinion
II	☐	Priority
III	☐	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	☒	Lack of unity of invention
V	☒	Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	☐	Certain document cited
VII	☐	Certain defects in the international application
VIII	☐	Certain observations on the international application

3. The applicant is hereby **invited to reply** to this opinion.

When? See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also: For an additional opportunity to submit amendments, see Rule 66.4. For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis. For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 15/10/2001.

Name and mailing address of the international preliminary examining authority:
European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized officer / Examiner
Meinl, W

Formalities officer (incl. extension of time limits)
Corcos, E
Telephone No. +49 89 2399 7418

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I. Basis of the opinion

1. With regard to the **elements** of the international application (Replacement *sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed"*):

Description, pages:

1-28 as originally filed

Claims, No.:

1-45 as originally filed

Drawings, sheets:

1-6 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation (Form PCT/IPEA/405) to restrict or pay additional fees, the applicant has:

   ☐ restricted the claims.

   ☒ paid additional fees.

   ☐ paid additional fees under protest.

   ☐ neither restricted nor paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied with for the following reasons and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees:

3. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this opinion:

   ☒ all parts.

   ☐ the parts relating to claims Nos. .

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-4,9,12,13,16-19,24,31-34,39
Inventive step (IS)	Claims	5-7,10,14,15,20-22,25-29,35-37,40-44
Industrial applicability (IA)	Claims	

2. Citations and explanations
   see separate sheet

Re. Section IV (Lack of unity of invention)

1. The following documents are referred to in this communication; the numbering will be adhered to in the rest of the procedure:-

   D1, D2: The documents of the International Search Report in the order as they are listed therein.

   D3: J. R. Smith and B. O. Comiskey: "Modulation and Information Hiding in Images", Lecture Notes in Computer Science, Springer Verlag, NY, US, Vol.1174, pp 207-226, May 1996; XP000992404 (cited at page 5 of the description, copy enclosed).

2. The application does not meet the requirement for unity of invention of Articles 3(4)(iii), 34(3) and Rule 13.1 PCT (see also the point 2. of the official letter of 23.02.01).
   As it has been already detailed in the annex to the partial search report of 28/09/2000, the application contains **two** different groups of claimed inventions:-

   Claimed invention (i): Claims 1, 9, 16, 24, 31 and 39 concern encoding of a function in a first image region and using that function for encoding data in a second image region.

   Claimed invention (ii): Claims 5, 10, 20, 25, 35 and 40 concern encoding of data in an upsampled image, e.g. for watermarking.

2.1 While one may say that the claimed inventions (i) and (ii) both relate to encoding of data in an image, this nevertheless does not provide for the required novel and inventive concept in that this generic concept is known from each of documents **D1** and **D2.**

Claimed invention (i):

Re. Sections V, VII, VIII (Novelty, Inventive step, Defects and Observations)

3. There seems to be a substantial inconsistency between the independent claims of the first claimed invention and the associated portions of the description (Art.6 PCT).

3.1 For instance, claim 1 states that a "first function" is encoded in a "first portion" of an image, and that data is encoded, using that "first function", in a "second portion" of the image. On the contrary, from the description page 6, lines 8-20 and page 21, lines 10-18 and from Fig.5 it appears that data is encoded - one bit per image region - in both the first and second "set of image regions" by means of correlation or anti-correlation, and that no "first function" is encoded. Actually, the first claimed invention seems to expressly avoid encoding of a "first function" in the stego-image, so as to prevent recovering the cover image (see the above citations at pp. 6, 21).

3.2 Correlation techniques usually require two comparable sets of data that can be correlated or whose correlation can be determined. This means that the current wording of claim 1 is totally inappropriate to reflect the first claimed invention as set out in the description. While the basic idea of the first claimed invention is reflected by claim 4, this is irrelevant to the question of clarity of claim 1 as long as claim 1 per se is misleading.
Clarification of that issue is required before a full substantive examination can be carried out for the first claimed invention.

4. In a preliminary view the novelty objection against the current method claims 1-4 is maintained.

4.1 It seems that the claims 1-4 lack novelty over **D1** (see abstract; col.2, line 46 - col.3, line 14; col.4, line 27 - col.5, line 46).
Regarding the claims 2 - 4 it is noted that the terms "bitwise modulation" (claim 2), "arbitrarily-selected disjoint sets" (claim 3) and "correlations and anti-correlations" (claim 4) do not have a clear and definite meaning in the art in the context of current claim 1 and that these terms therefore would not appear suitable to provide any clear distinction over D1.

4.2 Moreover, regarding claim 4, the feature "correlations and anti-correlations" is too unspecific in view of the "Patchwork algorithm" disclosed in **D3**, see page 212, 3rd complete paragraph). The Patchwork algorithm uses a pair of pixels, increases the brightness value of one member of the pair, and decreases the brightness of the other pixel by the same amount. In terms of the claims, the Patchwork algorithm uses pixels of a first and second portion of the image, and also uses a correlation of some kind between pixels of the two image portions.
Hence, one can also argue that claim 4, even when interpreted in the light of the description, lacks novelty over **D3** (Art.33(2) PCT).

4.3 It however appears that a substantially amended claim 1 that closely bases on the description (see the point 3.1 above), and that duly reflects the "first aspect" of the invention and includes features that clearly distinguish the claim from D3, might be novel and inventive over the prior art on file. A final judgement however is deferred until amended claims are filed.

5. The independent claims for encoding and decoding are not consistent in their scope, thus rendering the whole set of claims unclear and also not concise (Art.6 PCT).

Claimed invention (ii):

Re. Sections V, VII, VIII (Novelty, Inventive step, Defects and Observations)

6. It seems that claim 5 is incomplete and thus unclear (Art.6 PCT). The claim is completely silent as to how the data is actually encoded in the upsampled image.

7. Regarding inventive step the following is held.
The first feature ("upsampling ...") is trivial per se and commonly known for converting the image resolution e.g. for adaptation to a certain output device such as a printer. The second feature ("encoding") merely states that data is to be encoded in the upsampled image and is trivial per see too (Art.33(3) PCT).

The mere combination of "upsampling" and "encoding" is a juxtaposition of known features and thus trivial; in the current wording it does not provide any surprising effects.
Generic concepts of encoding of data in raw and compressed (video) images are known from **D2**, see items 3. and 4.

8. Dependent claims.
- Claim 6 seems to be unclear too (Art.6 PCT). The claim uses a disclaimer-type feature "is unchanged" while being silent as to what actually happens when encoding data.
- Claim 7: The feature "bitwise modulation" is trivial in the context of stego-images, see each of documents D1 to D3.
- Claim 8: The features of claim 8 are not known nor obvious from the prior art on file. An amended claim 5 should therefore include the features of claim 8.

9. The above objections apply to the device and memory claims accordingly.

General remarks for both claimed inventions.

10. When amending the application, the following formal points should also be dealt with:-
- The prior art disclosed in D1 should be briefly acknowledged in the description (Rule 5.1 (a) (ii) PCT).
- The statement of invention should be made consistent with the claims.

*****

103140-0007 PCT
NYT/PAS

PCT/US00/16099

PCT

N/A

INFORMATION CONCERNING ELECTED OFFICES NOTIFIED OF THEIR ELECTION

(PCT Rule 61.3)

From the INTERNATIONAL BUREAU

RECEIVED
MAY 21 2001
CESARI & MCKENNA

To:

GAGNE, Christopher, K.
Cesari and McKenna, LLP
88 Black Falcon Avenue
Boston, MA 02210
ETATS-UNIS D'AMERIQUE

Date of mailing (day/month/year) 11 May 2001 (11.05.01)	
Applicant's or agent's file reference 103140-7PCT	**IMPORTANT INFORMATION**

International application No.	**International filing date** (day/month/year)	**Priority date** (day/month/year)
PCT/US00/16099	13 June 2000 (13.06.00)	15 June 1999 (15.06.99)

Applicant
THE ESCHER GROUP, LTD. et al

1. The applicant is hereby informed that the International Bureau has, according to Article 31(7), notified each of the following Offices of its election:

   AP :GH,GM,KE,LS,MW,MZ,SD,SL,SZ,TZ,UG,ZW
   EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
   National :AU,BG,CA,CN,CZ,DE,IL,JP,KP,KR,MN,NO,NZ,PL,RO,RU,SE,SK,US

2. The following Offices have waived the requirement for the notification of their election; the notification will be sent to them by the International Bureau only upon their request:

   EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
   OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
   National :AE,AL,AM,AT,AZ,BA,BB,BR,BY,CH,CR,CU,DK,DM,EE,ES,FI,GB,GD,GE,GH,
   GM,HR,HU,ID,IN,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MW,MX,PT,SD,
   SG,SI,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW

3. The applicant is reminded that he must enter the "national phase" **before the expiration of 30 months from the priority date** before each of the Offices listed above. This must be done by paying the national fee(s) and furnishing , if prescribed, a translation of the international application (Article 39(1)(a)), as well as, where applicable, by furnishing a translation of any annexes of the international preliminary examination report (Article 36(3)(b) and Rule 74.1).

   Some offices have fixed time limits expiring later than the above-mentioned time limit. For detailed information about the applicable time limits and the acts to be performed upon entry into the national phase before a particular Office, see Volume II of the PCT Applicant's Guide.

   The entry into the European regional phase is postponed **until 31 months from the priority date** for all States designated for the purposes of obtaining a European patent.

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer: Kiwa Mpay KMP
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

Form PCT/IB/332 (September 1997)

4018729

\TENT COOPERATION TREATY

PAS/MYT 103140-6007 WO

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

RECEIVED FEB 15 2001 CESARI & MCKENNA

NA **PCT**

To:
SHEEHAN, Patricia A.
CESARI & MCKENNA, LLP
88 Black Falcon Avenue
BOSTON, MASSACHUSETTS 02210
ETATS-UNIS D'AMERIQUE

EINSCHREIBEN

NOTIFICATION OF RECEIPT OF DEMAND BY COMPETENT INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

(PCT Rules 59.3(e) and 61.1(b), first sentence and Administrative Instructions, Section 601(a))

Date of mailing *(day/month/year)*	07-02-2001
Applicant's or agent's file reference: 103140-7PCT	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US 00/16099	13/06/2000	15/06/1999

Applicant: THE ESCHER GROUP, LTD. et al.

1. The applicant is hereby **notified** that this International Preliminary Examining Authority considers the following date as the date of receipt of the demand for international preliminary examination of the international application:

11/01/2001

2. This date of receipt is:

- [X] the actual date of receipt of the demand by this Authority (Rule 61.1(b)).
- [ ] the actual date of receipt of the demand on behalf of this Authority (Rule 59.3(e)).
- [ ] the date on which this Authority has, in response to the invitation to correct defects in the demand (Form PCT/IPEA/404), received the required corrections.

3. [ ] **ATTENTION:** That date of receipt is **AFTER** the expiration of 19 months from the priority date. Consequently, the election(s) made in the demand does (do) not have the effect of postponing the entry into the national phase until 30 months from the priority date (or later in some Offices) (Article 39(1)). Therefore, the acts for entry into the national phase must be performed within 20 months from the priority date (or later in some Offices) (Article 22). For details, see the *PCT Applicant's Guide*, Volume II.

[ ] *(If applicable)* This notification confirms the information given by telephone, facsimile transmission or in person on: _____

4. Only where paragraph 3 applies, a copy of this notification has been sent to the International Bureau.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. (+49-89) 2399-0, Tx: 523656 epmu d Fax: (+49-89) 2399-4465	NOVELLI C Tel. (+49-89) 2399-8641

EUROPÄISCHES PATENTAMT · EUROPEAN PATENT OFFICE · OFFICE EUROPÉEN DES BREVETS

\TENT COOPERATION TREATY

Response Correct Defects 3/7/01

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

FAXED IN ADVANCE

INVITATION TO CORRECT DEFECTS IN THE DEMAND

(PCT Rule 60.1)

To:
SHEEHAN, Patricia A.
CESARI & MCKENNA, LLP
88 Black Falcon Avenue
BOSTON, MASSACHUSETTS 02210
ETATS-UNIS D'AMERIQUE

REGISTERED MAIL

Date of mailing *(day/month/year)* 07-02-2001

Applicant's or agent's file reference
103140-7PCT

REPLY DUE within **ONE MONTH** from the above date of mailing. See also below.

International application No.
PCT/US 00/16099

International filing date *(day/month/year)*
13/06/2000

Applicant
THE ESCHER GROUP, LTD. et al.

The applicant is hereby **invited** within the time limit indicated above **to correct the following defects** which this International Preliminary Examining Authority has found in the demand for international preliminary examination:

1. ☐ It does not contain the election of at least one Contracting State bound by Chapter II (Rules 53.2(a)(iv) and 53.7).
2. ☐ It does not permit identification of the international application to which it relates (Rule 60.1(b)).
3. ☐ It does not contain the required petition (Rules 53.2(a)(i) and 53.3).
4. ☒ It does not contain the required indications concerning the agent as specified in the Annex (Rules 53.2(a)(ii) and 53.5).
5. ☐ It does not contain the required indications concerning the international application as specified in the Annex (Rules 53.2(a)(iii) and 53.6).
6. ☐ It is not submitted in the required language which is: _____ (Rule 55.1).
7. ☐ It is not made on the printed form (rule 53.1(a)).
8. ☐ It is presented as a computer print-out the particulars of which do not comply with the Administrative Instructions (Rule 53.1(a)).
9. ☐ It does not contain the required indications concerning the applicant as specified in the Annex (Rules 53.2(a)(ii) and 53.4).
10. ☐ It does not contain the required signature as specified in the Annex (Rules 53.2(b) and 53.8).

Effects of the date of receipt of the corrections on the date of receipt of the demand:

(i) If the defects noted under items 1 and 2 are corrected within the time limit indicated above, the demand shall be considered as if it had been received on the date when the corrections are received (Rule 60.1(b)). If that date is later than the expiration of 19 months from the priority date, entry into the national phase before the elected Offices will **NOT** be postponed until the expiration of 30 months from the priority date.

(ii) If the defects noted under items 3 to 10 are corrected within the time limit indicated above, the demand shall be considered as if it had been received on its actual filing date (Rule 60.1(b)).

Effects of failure to correct the defects within the time limit indicated above:

(i) In the case of defects noted under items 1 to 8, this Authority will declare that the demand is considered as if it had not been submitted

(ii) In the case of defects noted under items 9 and 10, this Authority will declare that the election(s) of the State(s) concerned is (are) considered as if it (they) had not been made.

A copy of this invitation has been sent to the International Bureau.

Name and mailing address of the IPEA/
European Patent Office
D-80298 Munich
Tel. (+49-89) 2399-0, Tx: 523656 epmu d
Fax: (+49-89) 2399-4465

Authorized officer
NOVELLI C
Tel. (+49-89) 2399-8641

EUROPÄISCHES PATENTAMT · EUROPEAN PATENT OFFICE · OFFICE EUROPÉEN DES BREVETS

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ANNEX TO
FORM PCT/IPEA/404

International application No.
PCT/US 00/16099

Continuation of item 4: As to indications concerning **the agent** (Rule 4.4), the demand:

a. ☐ does not properly indicate the agent's name *(specify)*:

b. ☐ does not indicate the agent's address.

c. ☒ does not properly indicate the agent's address *(specify)*:

on the form 101: Postcode: 02110
on the form 401: Postcode: 02210
Please clarify

Continuation of item 5: As to indications concerning **the international application,** the demand does not indicate:

a. ☐ the international filing date.

b. ☐ the international application number.

c. ☐ the name of the receiving Office, where the international application number was not known to the applicant at the time the demand was filed.

d. ☐ the title of the invention.

Continuation of item 9: As to indications concerning **the applicant** (Rules 4.4 and 4.5), the demand:

a. ☐ does not indicate all the applicants for the elected States.

b. ☐ does not properly indicate the applicant's name *(specify)*:

c. ☐ does not indicate the applicant's address.

d. ☐ does not properly indicate the applicant's address *(specify)*:

e. ☐ does not indicate the applicant's nationality.

f. ☐ does not indicate the applicant's residence.

Continuation of item 10: As to indications concerning **signature** (Rules 4.15 and 90.4), the demand:

a. ☐ is not signed.

b. ☐ is not signed by all the applicants for the elected States.

c. ☐ is not accompanied by the statement referred to in the check list in Box No. VI of the demand explaining the lack of the signature of an applicant for the election of the United States of America.

d. ☐ is signed by what appears to be an agent/common representative but

☐ the demand is not accompanied by a power of attorney appointing him.

☐ the power of attorney accompanying the demand is not signed by all the applicants for the elected States.

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

GAGNE, Christopher, K.
Cesari and McKenna, LLP
88 Black Falcon Avenue
Boston, MA 02110
ETATS-UNIS D'AMERIQUE

Date of mailing (day/month/year) 12 September 2000 (12.09.00)	
Applicant's or agent's file reference 103140-7PCT	**IMPORTANT NOTIFICATION**
International application No. PCT/US00/16099	International filing date (day/month/year) 13 June 2000 (13.06.00)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 15 June 1999 (15.06.99)
Applicant THE ESCHER GROUP, LTD. et al	

1. The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).

2. This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.

3. An **asterisk(*)** appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

4. The **letters "NR"** appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, **the attention of the applicant is directed** to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
15 June 1999 (15.06.99)	60/139,758	US	17 July 2000 (17.07.00)

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

Sean Taylor

Telephone No. (41-22) 338.83.38

INFORMATION ON TIME LIMITS FOR ENTERING THE NATIONAL PHASE

The applicant is reminded that the "national phase" must be entered before each of the designated Offices indicated in the Notification of Receipt of Record Copy (Form PCT/IB/301) by paying national fees and furnishing translations, as prescribed by the applicable national laws.

The time limit for performing these procedural acts is **20 MONTHS** from the priority date or, for those designated States which the applicant elects in a demand for international preliminary examination or in a later election, **30 MONTHS** from the priority date, provided that the election is made before the expiration of 19 months from the priority date. Some designated (or elected) Offices have fixed time limits which expire even later than 20 or 30 months from the priority date. In other Offices an extension of time or grace period, in some cases upon payment of an additional fee, is available.

In addition to these procedural acts, the applicant may also have to comply with other special requirements applicable in certain Offices. **It is the applicant's responsibility** to ensure that the necessary steps to enter the national phase are taken in a timely fashion. Most designated Offices do not issue reminders to applicants in connection with the entry into the national phase.

For detailed information about the procedural acts to be performed to enter the national phase before each designated Office, the applicable time limits and possible extensions of time or grace periods, and any other requirements, see the relevant Chapters of Volume II of the PCT Applicant's Guide. Information about the requirements for filing a demand for international preliminary examination is set out in Chapter IX of Volume I of the PCT Applicant's Guide.

GR and ES became bound by PCT Chapter II on 7 September 1996 and 6 September 1997, respectively, and may, therefore, be elected in a demand or a later election filed on or after 7 September 1996 and 6 September 1997, respectively, regardless of the filing date of the international application. (See second paragraph above.)

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

CONFIRMATION OF PRECAUTIONARY DESIGNATIONS

This notification lists only specific designations made under Rule 4.9(a) in the request. It is important to check that these designations are correct. Errors in designations can be corrected where precautionary designations have been made under Rule 4.9(b). The applicant is hereby reminded that any precautionary designations may be confirmed according to Rule 4.9(c) before the expiration of 15 months from the priority date. If it is not confirmed, it will automatically be regarded as withdrawn by the applicant. There will be no reminder and no invitation. Confirmation of a designation consists of the filing of a notice specifying the designated State concerned (with an indication of the kind of protection or treatment desired) and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.

REQUIREMENTS REGARDING PRIORITY DOCUMENTS

For applicants who have not yet complied with the requirements regarding priority documents, the following is recalled.

Where the priority of an earlier national, regional or international application is claimed, the applicant must submit a copy of the said earlier application, certified by the authority with which it was filed ("the priority document") to the receiving Office (which will transmit it to the International Bureau) or directly to the International Bureau, before the expiration of 16 months from the priority date, provided that any such priority document may still be submitted to the International Bureau before that date of international publication of the international application, in which case that document will be considered to have been received by the International Bureau on the last day of the 16-month time limit (Rule 17.1(a)).

Where the priority document is issued by the receiving Office, the applicant may, instead of submitting the priority document, request the receiving Office to prepare and transmit the priority document to the International Bureau. Such request must be made before the expiration of the 16-month time limit and may be subjected by the receiving Office to the payment of a fee (Rule 17.1(b)).

If the priority document concerned is not submitted to the International Bureau or if the request to the receiving Office to prepare and transmit the priority document has not been made (and the corresponding fee, if any, paid) within the applicable time limit indicated under the preceding paragraphs, any designated State may disregard the priority claim, provided that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity to furnish the priority document within a time limit which is reasonable under the circumstances.

Where several priorities are claimed, the priority date to be considered for the purposes of computing the 16-month time limit is the filing date of the earliest application whose priority is claimed.

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103140-6007WO
NK CKG/MY

PATENT COOPERATION TREATY

PCT

From the INTERNATIONAL BUREAU

To:

GAGNE, Christopher, K.
Cesari and McKenna, LLP
30 Rowes Wharf
Boston, MA 02110
ETATS-UNIS D'AMERIQUE

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

Date of mailing (day/month/year)	IMPORTANT NOTIFICATION
03 August 2000 (03.08.00)	
Applicant's or agent's file reference	**International application No.**
103140-7PCT	PCT/US00/16099

The applicant is hereby notified that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

THE ESCHER GROUP, LTD. (for all designated States except US)
SMITH, Joshua, R. (for US)

International filing date	:	13 June 2000 (13.06.00)
Priority date(s) claimed	:	15 June 1999 (15.06.99)
Date of receipt of the record copy by the International Bureau	:	05 July 2000 (05.07.00)
List of designated Offices	:	

AP :GH,GM,KE,LS,MW,MZ,SD,SL,SZ,TZ,UG,ZW
EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
National :AE,AL,AM,AT,AU,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CR,CU,CZ,DE,DK,DM,EE,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KP,KR,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,NO,NZ,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,US,UZ,VN,YU,ZA,ZW

ATTENTION

The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau.

In addition, the applicant's attention is drawn to the information contained in the Annex, relating to:

- [X] time limits for entry into the national phase
- [X] confirmation of precautionary designations
- [X] requirements regarding priority documents

A copy of this Notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:

Philippe Bécamel

Telephone No. (41-22) 338.83.38

This sheet is not part of and does not count as a sheet of the international application.

PCT

FEE CALCULATION SHEET
Annex to the Request

For receiving Office use only

International application No.

Date stamp of the receiving Office

Applicant's or agent's file reference: 103140-7PCT

Applicant: THE ESCHER GROUP, LTD.

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE . . . . . 240 T

2. SEARCH FEE . . . . . 925 S

International search to be carried out by EPO

(If two or more International Searching Authorities are competent in relation to the international application, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

The international application contains 49 sheets.

first 30 sheets 427 b1

19 (remaining sheets) x 10 (additional amount) = 190 b2

Add amounts entered at b1 and b2 and enter total at B . . . . 617 B

Designation Fees

The international application contains ALL designations.

8 (number of designation fees payable *(maximum 8)*) x 92 (amount of designation fee) = 736 D

Add amounts entered at B and D and enter total at I . . . . . 1353 I

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and D.)

4. FEE FOR PRIORITY DOCUMENT *(if applicable)* . . . . . 15 P

5. TOTAL FEES PAYABLE . . . . . 2533 USD

Add amounts entered at T, S, I and P, and enter total in the TOTAL box — TOTAL

☐ The designation fees are not paid at this time.

MODE OF PAYMENT

☐ authorization to charge deposit account (see below)	☐ bank draft	☐ coupons
☒ cheque	☐ cash	☐ other *(specify)*:
☐ postal money order	☐ revenue stamps	

DEPOSIT ACCOUNT AUTHORIZATION *(this mode of payment may not be available at all receiving Offices)*

The RO/ US

☐ is hereby authorized to charge the total fees indicated above to my deposit account.

☒ *(this check-box may be marked only if the conditions for deposit accounts of the receiving Office so permit)* is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account.

☐ is hereby authorized to charge the fee for preparation and transmittal of the priority document to the International Bureau of WIPO to my deposit account.

03-1237 — Deposit Account No.

13/JUNE/2000 — Date *(day/month/year)*

Signature — Reg. No. 36,142

Form PCT/RO/101 (Annex) (January 2000)

See Notes to the fee calculation sheet

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* 103140-7PCT

Box No. I TITLE OF INVENTION

DATA ENCODING AND DECODING

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

THE ESCHER GROUP, LTD.
101 Main Street, 12th Floor
Cambridge, Massachusetts 02142

United States of America

☐ This person is also inventor.

Telephone No.
(617) 234-8910

Facsimile No.
(617) 497-3910

Teleprinter No.

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

SMITH, Joshua R.
194 Norfolk Street
Cambridge, Massachusetts 02139

United States of America

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

GAGNE, Christopher K.
Cesari and McKenna, LLP
30 Rowes Wharf
Boston, Massachusetts 02110

United States of America

Telephone No.
(617) 951-3050

Facsimile No.
(617) 951-3927

Teleprinter No.

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- [X] **AP** **ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, TZ United Republic of Tanzania, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- [X] **EA** **Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- [X] **EP** **European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- [X] **OA** **OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

- [X] **AE** United Arab Emirates
- [X] **AL** Albania
- [X] **AM** Armenia
- [X] **AT** Austria
- [X] **AU** Australia
- [X] **AZ** Azerbaijan
- [X] **BA** Bosnia and Herzegovina
- [X] **BB** Barbados
- [X] **BG** Bulgaria
- [X] **BR** Brazil
- [X] **BY** Belarus
- [X] **CA** Canada
- [X] **CH and LI** Switzerland and Liechtenstein
- [X] **CN** China
- [X] **CR** Costa Rica
- [X] **CU** Cuba
- [X] **CZ** Czech Republic
- [X] **DE** Germany
- [X] **DK** Denmark
- [X] **DM** Dominica
- [X] **EE** Estonia
- [X] **ES** Spain
- [X] **FI** Finland
- [X] **GB** United Kingdom
- [X] **GD** Grenada
- [X] **GE** Georgia
- [X] **GH** Ghana
- [X] **GM** Gambia
- [X] **HR** Croatia
- [X] **HU** Hungary
- [X] **ID** Indonesia
- [X] **IL** Israel
- [X] **IN** India
- [X] **IS** Iceland
- [X] **JP** Japan
- [X] **KE** Kenya
- [X] **KG** Kyrgyzstan
- [X] **KP** Democratic People's Republic of Korea
- [X] **KR** Republic of Korea
- [X] **KZ** Kazakhstan
- [X] **LC** Saint Lucia
- [X] **LK** Sri Lanka
- [X] **LR** Liberia
- [X] **LS** Lesotho
- [X] **LT** Lithuania
- [X] **LU** Luxembourg
- [X] **LV** Latvia
- [X] **MA** Morocco
- [X] **MD** Republic of Moldova
- [X] **MG** Madagascar
- [X] **MK** The former Yugoslav Republic of Macedonia
- [X] **MN** Mongolia
- [X] **MW** Malawi
- [X] **MX** Mexico
- [X] **NO** Norway
- [X] **NZ** New Zealand
- [X] **PL** Poland
- [X] **PT** Portugal
- [X] **RO** Romania
- [X] **RU** Russian Federation
- [X] **SD** Sudan
- [X] **SE** Sweden
- [X] **SG** Singapore
- [X] **SI** Slovenia
- [X] **SK** Slovakia
- [X] **SL** Sierra Leone
- [X] **TJ** Tajikistan
- [X] **TM** Turkmenistan
- [X] **TR** Turkey
- [X] **TT** Trinidad and Tobago
- [X] **TZ** United Republic of Tanzania
- [X] **UA** Ukraine
- [X] **UG** Uganda
- [X] **US** United States of America
- [X] **UZ** Uzbekistan
- [X] **VN** Viet Nam
- [X] **YU** Yugoslavia
- [X] **ZA** South Africa
- [X] **ZW** Zimbabwe

Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet:

- [ ] .....
- [ ] .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)*

Supplemental Box *If the Supplemental Box is not used, this sheet should not be included in the request.*

1. If, in any of the Boxes, the space is insufficient to furnish all the information: in such case, write "Continuation of Box No. ..." [indicate the number of the Box] and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient, in particular:

(i) if more than two persons are involved as applicants and/or inventors and no "continuation sheet" is available: in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below;

(ii) if, in Box No. II or in any of the sub-boxes of Box No. III, the indication "the States indicated in the Supplemental Box" is checked: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant;

(iii) if, in Box No. II or in any of the sub-boxes of Box No. III, the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the inventor(s) and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor;

(iv) if, in addition to the agent(s) indicated in Box No. IV, there are further agents: in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV;

(v) if, in Box No. V, the name of any State (or OAPI) is accompanied by the indication "patent of addition," or "certificate of addition," or if, in Box No. V, the name of the United States of America is accompanied by an indication "continuation" or "continuation-in-part": in such case, write "Continuation of Box No. V" and the name of each State involved (or OAPI), and after the name of each such State (or OAPI), the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application;

(vi) if, in Box No. VI, there are more than three earlier applications whose priority is claimed: in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI;

(vii) if, in Box No. VI, the earlier application is an application for the grant of a regional patent: in such case, write "Continuation of Box No. VI", specify the number of the earlier application and indicate for each additional earlier application the same type of information as required in Box No. VI;

(viii) if, in Box No. VI, the earlier application is an application for the grant of a patent in or for any country party to the Paris Convention for the Protection of Industrial Property or one Member of an intergovernmental organization: in such case, write "Continuation of Box No. VI", specify the number of the earlier application and indicate for each additional earlier application the same type of information as required in Box No. VI;

2. If, with regard to the precautionary designation statement contained in Box No. V, the applicant wishes to exclude any State(s) from the scope of that statement: in such case, write "Designation(s) excluded from precautionary designation statement" and indicate the name or two-letter code of each State so excluded.

3. If the applicant claims, in respect of any designated Office, the benefits of provisions of the national law concerning non-prejudicial disclosures or exceptions to lack of novelty: in such case, write "Statement concerning non-prejudicial disclosures or exceptions to lack of novelty" and furnish that statement below.

(CONT. BOX IV)

ATTAYA, Michael E.
BARBAS, Charles J.
BORN, Joseph H.
CESARI, Robert A.
CHOI, Yong
FRANK, Steven J.
GAGNE, Christopher K.
JOHNSTON, A. Sidney
LOGINOV, William A.
MCKENNA, John F.
NATH, Rama B.
O'DONNELL, Martin J.
O'KONSKI, Thomas C.
PAUL, Edwin H.
REINEMANN, Michael R.
ROONEY, Rita A.
SHAPIRO, Heather B.
SHEEHAN, Patricia A.
STECEWYCZ, Joseph

CESARI AND MCKENNA, LLP
30 Rowes Wharf
Boston, MA 02110

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) (15.06.99) 15 June 1999	60/139,758	US		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): (1)

** Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)* :

ISA / EPO

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority)*:

Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following **number of sheets**:

request	4
description (excluding sequence listing part)	28
claims	10
abstract	1
drawings	6
sequence listing part of description	–
Total number of sheets	49

This international application is **accompanied** by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☒ separate signed power of attorney
3. ☐ copy of general power of attorney, reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☐ other *(specify)*:

Figure of the drawings which should accompany the abstract: FIG. 1

Language of filing of the international application: ENGLISH

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Christopher K. Gagne
Reg. No. 36,142

For receiving Office use only

1. Date of actual receipt of the purported international application:
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority (if two or more are competent): ISA / EP
6. ☐ Transmittal of search copy delayed until search fee is paid.

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

To:
CESARI & MCKENNA, LLP
Attn. GAGNE, Christopher
88 Black Falcon Avenue
BOSTON, MASSACHUSETTS 02110
UNITED STATES OF AMERICA

Date of mailing *(day/month/year)* 12/01/2001	
Applicant's or agent's file reference 103140-7PCT	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/US 00/16099	International filing date *(day/month/year)* 13/06/2000
Applicant THE ESCHER GROUP, LTD.	

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Cornelia Schulze

Form PCT/ISA/220 (July 1998)

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions, respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped),whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."

2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."

3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."

4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments and any accompanying statement, under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the time of filing the amendments (and any statement) with the International Bureau, also file with the International Preliminary Examining Authority a copy of such amendments (and of any statement) and, where required, a translation of such amendments for the procedure before that Authority (see Rules 55.3(a) and 62.2, first sentence). For further information, see the Notes to the demand form (PCT/IPEA/401).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENTS
103140-0007PCT

INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY
EUROPEAN PATENT OFFICE

In Re The International Application of:
The Escher Group, Ltd.

International Application No.:
PCT/US00/16099

International Filing Date: June 13, 2000

For: DATA ENCODING AND DECODING

Application File No. 103140-0007PCT

Cesari and McKenna, LLP
88 Black Falcon Avenue
Boston, MA 02210
August 27, 2001

VIA FACSIMILE AND OVERNIGHT COURIER

European Patent Office
D-60298 Munich
+49 89 2399-4465

RESPONSE TO WRITTEN OPINION

Sirs:

This is a Response to the Written Opinion dated June 28, 2001 (Response date August 28, 2001).

Paragraphs 3, 4, 5

With regard to the discussion of claims 1-4, we have amended claim 1 to point out that pixels in a first portion of the image are manipulated in accordance with a first function and pixels in a second portion of the image are manipulated in accordance with the first function and the data, in order to encode the data into the image. Similar amendments have been made to the corresponding decoding and apparatus claims.

The D1 reference, which was cited against claims 1-4, describes encoding a first portion of an image in accordance with a hash function and recording the result of the hash or an encrypted version the result in a second portion of the image. The user thereafter determines if the image is altered by again encoding the first portion of the image in accordance with the same, externally provided hash function and essentially comparing the result with the hash result that was included in the second portion of the image.

Using the current system, the data can be decoded from the image by determining if corresponding regions of the first and second portions are positively or negatively correlated. Accordingly, the current system encodes the data into the image such that the data can be decoded without knowledge of the function used to encode the data. In contrast, the system used in the D1 reference requires that the decoder use the same hash function as the encoder. Accordingly, the D1 reference does not show, teach or suggest the current invention.

Paragraphs 6, 7, 8, 9

With regard to the discussion of claim 5, we have amended the claim to state that the upsampled image is encoded to produce an encoded image in which the first image, that is, the original image from which the upsample image was generated, does not interfere with the data. As discussed in the application, one example of such an encoded upsampled image is one in which the intensity value of a predetermined pixel in each respective group of identical pixels is retained in the encoded image (claim 6). Another example of such an encoded upsampled image is one in which the intensities of the pixels in the respective groups sum to the intensity values of corresponding

pixels in the original image (claim 8). We have made similar amendments to the corresponding decoding and apparatus claims.

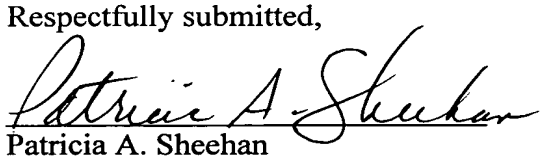
The encoding method described in amended claim 5, and the corresponding decoding and apparatus claims is not shown, taught or suggested by the cited references.

Paragraph 10

We have included an acknowledgement of D1, and we have made the statement of the invention consistent with the claims in replacement pages 5-6a.

It is respectively submitted that all matters raised by the Examiner with respect to Section V, VII and VIII have been addressed herein and no new matter has been entered which is beyond the scope of the original application as filed.

Respectfully submitted,



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PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 11 May 2001 (11.05.01)	
International application No. PCT/US00/16099	**Applicant's or agent's file reference** 103140-7PCT
International filing date (day/month/year) 13 June 2000 (13.06.00)	**Priority date** (day/month/year) 15 June 1999 (15.06.99)
Applicant SMITH, Joshua, R.	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

11 January 2001 (11.01.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Kiwa Mpay
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